PHENOLOGICAL RECORDS IN CARPATHIANS IN 19TH CENTURY AND THEIR POSSIBLE USE

REGISTRAZIONI FENOLOGICHE NEI CARPAZI NEL XIX SECOLO E LORO POSSIBILE USO

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Abstract
First phenological observations in Carpathian region were done in the beginning of thirties of the 19th century in Orawicz by a medical doctor P. Wierbitzky (Nekovář, 2008). Nevertheless, first systematic observations and records of plant development in this region are connected with the establishment of Austrian Institute for Meteorology and Geomagnetism since 1851. Though the historical significance of these observations is high the data recorded are of low quality, frequently interrupted and fragmented.

Further development of phenological observations came with the methodology of observations introduced by Karl Fritsch in the beginning of sixties but mainly with the establishment of Hungarian Meteorological Service in 1871. Data from the period 1871-1885 were recorded and published in the yearbooks and despite of the fragmentary character of the records they are usable for some evaluations. This article brings the description of the data sets of systematic phenological network in Carpathian region and considers some possible phenological evaluations.

Keywords: phenological phase, plant development, phenological calendar

Introduction
Phenological observations have a long history. The oldest known phenological records in Central Europe are most probably the records about the vine harvest. One of them started as early as 1457 in Vienna which is on the border of Carpathian region (Lauscher, 1985).

Nevertheless, the first systematic phenological observations started in south Carpathians almost four hundred years later in consequence of the establishment of Austrian and later of Hungarian phenological network. The development and publishing of the guidelines for phenological observations by K. Fritsch (Fritsch, 1854), who also got a position at the Austrian Institute for Meteorology and Geomagnetism and run the observations, was very important for starting the systematic observation. The Fritsch’s guidelines were updated a few times. In 1863 he reduced the number of plants as well as the number of phenological phases to be observed with the recommendation to observe and to record the beginning (first appearance) of the phenological phase. The only exception was the phase of fall of leaves where the records should mention the “full” phase. He also recommended to monitor only one single individual and not the plant community. This methodology was also applied at the Hungarian phenological network by Moritz Staub since 1871. The data were collected once a year and published in the yearbooks with a delay of 2-3 years, together with the records of climatological observations. Both plant and animal phenological observations were recorded. Because of the fragmented character of the data only the records of plant phenology will be discussed in this article. There are some works from central Europe prolonging the agrometeorological evaluations to the 19th century (Možný et al., 2007), but as recognized in a survey on history and current status of phenology in Europe ((Nekovář et al. 2008) phenological evaluations from the 19th century are rather rare.
Data inventory
The phenological observations were done in some cases at the same localities as the climatological observations but the number of phenological stations was quite lower in the particular years.

All the material discussed in this work was taken from the Yearbooks issued by Hungarian Meteorological Service from 1871 to 1885 in Budapest. The phenological data disappeared from these yearbooks from 1886 without any notice. Some phenological observations were re-established at the end of 19th century by Kabos Hegyfoky but they were not included in the yearbooks from this period.

The records were based on the observation of four phenological phases: leafing, flowering, ripening and fall of leaves.

Both the quantity and the quality of the records vary from station to station. Leafing was recorded for a number of species varying from 7 to 40, flowering from about 100 to 400 species in particular years, while ripening from 15 to 30 species. In some cases data were given with metadata including geographical details regarding the position of observed individual plant, orientation of the slopes and also with the damages caused by frosts but this was not the general feature.

As seen in Table 1 there were almost no records for the fall of leaves so that the autumn phenology is practically missing. As expected the most visible phenological phases (leafing and flowering) have got the biggest number of records but also ripening was recorded with comparable perseverance. The number of records varied from year to year and the general statistics shows us 548 records of at least one phenological phase at one species in the fifteen years period. This represents about 23 % of potential records from all stations existing in the investigated period. However, the numbers of records strongly vary from year to year and mainly in 1871-73. In 1871 we could recognize the records from only five stations but four of them recorded all four phenological phases. 1871 and the following two years were the only years when it was possible to follow all the vegetation cycle from early spring to autumn at least at one station. There are no records about fall of leaves from 1874.

All the observations were done on voluntary basis so that the number of stations recording flowering and leafing varied from 4 to 27 with the decreasing number at ripening. There were found 53 stations with phenological records within Hungarian part of Austro-Hungary. The network was concentrated mostly to the northern part and to the south territories east from Tisza river, see Fig.1. Except for the station of Fiume, positioned at the Adriatic sea, the elevation of the stations spans from 90 m a.s.l. in Hungarian lowland to 600-1000 m a.s.l. in the Carpathian ridge.

20 out of 53 stations observed only for one season and only 4 stations observed for more than 10 years. More over, even the stations which performed the observations for more than 10

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### Table 1: Number of records of the particular phenological phase of all species in Carpathian region

<table>
<thead>
<tr>
<th>Phenophase</th>
<th>1871</th>
<th>1872</th>
<th>1873</th>
<th>1874</th>
<th>1875</th>
<th>1876</th>
<th>1877</th>
<th>1878</th>
<th>1879</th>
<th>1880</th>
<th>1881</th>
<th>1882</th>
<th>1883</th>
<th>1884</th>
<th>1885</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leafing</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>27</td>
<td>20</td>
<td>16</td>
<td>18</td>
<td>14</td>
<td>14</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Flowering</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>22</td>
<td>20</td>
<td>16</td>
<td>19</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>10</td>
<td>7</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Ripening</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>18</td>
<td>19</td>
<td>15</td>
<td>17</td>
<td>13</td>
<td>14</td>
<td>12</td>
<td>9</td>
<td>7</td>
<td>9</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Fall of leaves</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

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**Fig. 1** Phenological network in Hungary in 1871-85; 53 stations in total

**Fig. 1** - La rete fenologica in Ungheria nel periodo 1871-85; 53 stazioni in totale
years changed the observed species from year to year. This makes the data sets quite fragmented with many gaps and the standard statistical characteristics of any station can hardly be obtained and/or their statistical significance is very low. The longest records of 13 years were found at Nagy Szeben station in Transylvania, but even at these station the observations include many gaps and the observed species vary too much to use the data for standard statistical processing.

**Discussion on some evaluations**

As the standard statistical processing of the data sets was not possible we tried to elaborate some descriptions which can characterize the distribution of phenological manifestation in space and time. Climatological records available in the yearbooks are expressed in monthly mean values and totals. There are also gaps and missing data in the climatological records. Nevertheless, these data sets enable us to get general characteristics of months and seasons. Two stations with good data series available from the investigated region were selected to get the temperature characteristics of Budapest and Ógyalla. It was possible to compare temperature characteristics also with data from Vienna and Prague. The temperature mean of the period 1871-85 was about 0.5 °C colder than the last reference normal 1961-90 and about 1.3 °C colder than the last 15 years period from 1994 to 2008. We identified the year 1874 in which the temperature characteristics of the spring and the previous winter were close to the 1871–1885 mean. Fortunately, this year was the richest one in the phenological records regarding the number of stations. Flowering as the mostly observed phenological phase was selected for the phenological pattern of the year. Thus, we retrieved the phenological characteristics of some plants - Corylus avellana, Prunus spinosa, Aesculus hippocastanum, and Tilia cordata in 1874 for the spatial distribution in fig. 2-5. The same plants were also chosen to identify the be-
gimming of flowering of plants characterizing the start of early spring, late spring and early summer. The general step by step delay of the beginning of flowering of all species in the direction SW–NE is modified by the influence of the elevation. Gospic station is under the influence of Adriatic sea and the flowering date corresponds with the date of stations positioned much further to the north at the same elevation. The biggest difficulty in this type of phenological analysis is the fact that there was not any binding set of species which should be observed at each station and even very common particular species were observed at only few stations.

Next possible evaluation can follow the local phenological calendar. This was done also for the year 1874. As only three phenological phases were recorded it was difficult to follow the development and growth of a particular plant. That is why only flowering of the plants characterizing start of early spring (*Corylus avellana*), full spring (*Cornus mas, Salix alba* and *Prunus spinosa*), late spring (*Syringa vulgaris, Aesculus hippocastanum* and *Crataegus laevigata*) and early summer (*Robinia pseudoacacia* and *Sambucus nigra*) were considered. The full start of summer is usually indicated by flowering of *Tilia platyphyllos* and *Tilia cordata*. Three stations from the lowlands in northern region with relatively good data sets were selected in order to get this course of flowering, see Tab. 2. The most northern station, Nedanocz, shows the delay in the beginning of flowering for the plants which flower in full spring and early summer while the plants flowering in early spring show data comparable with other localities. Data in Tab. 2 were compared with the data of flowering from 1994-2008 from the localities close to the stations in Tab. 2. The comparisons show mostly 1-3 weeks sooner flowering. This corresponds with higher temperature from February to June by 1-1.5 °C.

**Conclusions**

The inventory of phenological records from the period of 1871-85 from Carpathian region showed pretty fragmented data sets which are not suitable for standard statistical evaluation. Some possibilities of phenological evaluations are in spatial and time analysis of the development of different plants in particular years/seasons which represent either the average climatic conditions or include also some climatic extremes. Deeper analysis of such phenological events will require daily temperature data. The advantage of above discussed data sets is the fact that one methodology of observations was applied and that they cover a pretty big area of Central Europe and a part of Balkan. Further development of phenological observations in the region after the fall of the Austro-Hungarian Empire was based on the conditions in particular country. It means changes in the methods of observations and in the number of stations. The recent cooperation in creating phenological databases brought considerable difficulties as some networks were canceled and re-established again in the 20th century.

**References**


