PHENOLOGICAL OBSERVATION SINCE THE DAYS OF LINNÉ IN FINLAND

OSSERVAZIONI FENOLOGICHE IN FINLANDIA DAL TEMPO DI LINNEO

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Abstract

In Finland, the oldest phenological observation series based on voluntary observers starts in the middle of the 1700s. In this paper we focus on a historical long-term dataset as well as on a newer network established for monitoring annual phenological events taking place in the same individual plants. In addition to the work in the field by voluntarious observers, several phenological monitoring surveys are nowadays carried out by different institutes as a part of Finnish national phenological network. Compilation and documentation of observations on plant phenophases play a key role in working out the rate of global climate change. In this context we present data on the onset of flowering in the rowan (*Sorbus aucuparia*) and the bird sherry (*Prunus padus*) that has become earlier in Finland at the rate of three days / century and five days / century, respectively. Phenological monitoring is nowadays more important than ever especially in boreal regions, where spring temperatures are elevated.

Keywords: Phenology, climate change, rowan, bird cherry

Riassunto

In Finlandia, le più antiche serie storiche di osservazioni fenologiche basate su osservatori volontari iniziano alla metà del 1700. In questo lavoro si pone l'attenzione sia su una lunga serie storica sia su una rete più recente, istituita per monitorare gli eventi fenologici annuali sulle stesse piante. Oltre al lavoro sul campo svolto dagli osservatori volontari, attualmente numerosi rilievi di monitoraggio fenologico sono effettuati da diversi istituti, facenti parte della rete fenologica nazionale finlandese.

*La compilazione e la documentazione delle osservazioni sulle fenofasi delle piante giocano un ruolo fondamentale nel calcolare il ritmo del cambiamento climatico globale. In questo contesto, vengono presentati i dati dell'inizio della fioritura del sorbo degli uccellatori (*Sorbus aucuparia*) e del pado (*Prunus padus*), che è diventata più precoce, in Finlandia, al ritmo, rispettivamente, di tre giorni/secolo e cinque giorni/secolo. Il monitoraggio fenologico è al giorno d'oggi più importante che mai, specialmente nelle regioni boreali, dove le temperature primaverili sono elevate.*

Parole chiave: *fenologia, cambiamento climatico, sorbo degli uccellatori, pado*

Introduction

"Years are not brothers" is an old Finnish phrase pointing out seasonal differences between years. Phenology focuses on documenting the onset of phenomena related to the annual phases of life cycles in plants, animals and mushrooms. Phenological field observations are usually considered in connection with concomitant temperature measurements obtained from the meteorological station nearest to the observation sites. Long-term observation series compiled during the run of decades or even centuries rely on the annual field work by voluntary observers. Such valuable datasets are gained in different countries including Finland. The pioneers of phenology hardly could imagine how valuable their observations would be for the research in the future.

The start of phenological observations in Finland dates back to the 1750s, i.e. to the days of the great nature scientist Carolus Linnaeus, later known as Carl von Linné. In a Swedish newspaper of his time called "Lärda tidningar" he suggested that the readers should carry out phenological observations. Four years later after his request, in 1753 the first Nordic dissertation "Vernatio Arborum" on phenology was published in the University of Uppsala, Sweden. Records from Finland were included and this is why we can say that phenology started simultaneously in Sweden and Finland. Two other publications from the 1700s concerning Finland are noteworthy in this context. They are the dissertation by Justander in 1786 called "Specimen Calendarii Florae et Faunae Åboënsis" ("Calendar for species of Flora and Fauna in Turku (=Åbo)") and a publication by Julin viz., "Anmärkningar om några Flyttfoglarnas ankomst och örters blomningstid mm. till upplysning af klimatet i Uhleåborg" ("Observations on the arrival of some migratory birds and flowering of plants in relation to the climate in Oulu (=Uhleåborg)" in 1789. In the latter work phenological observations and meteorological measurements made near and in the city of Oulu were associated. Old Finnish phenological observations from 1750 up to 1845 are indicated in a publication by Moberg (1856). Additional information on later phenological datasets were given by Johansson (1946).

At the beginning of phenological recording in Finland observations were received more or less regularly and it was not until in the 1840s when collecting phenological data was systematically organized. In 1846 The Finnish Society of Sciences and Letters (FSSL) undertook this task. It started annual collection of observations from volunteers. This way the survey continued until in the early 1960s when Zoological Museum belonging now to the Finnish Museum of Natural History (FMNH) continued to carry on the survey together with FSSL. Nowadays the cooperation between FSSL and FMNH is still going on. At the beginning of each year observers are provided with a summary of their observations from the previous year and concomitantly new forms and instructions for the next year are sent to the observers.

In this paper we present preliminary results from the observations series included in that long-term phenological material. The data refer to the onset of flowering in rowan (*Sorbus aucuparia*) and bird cherry (*Prunus padus*) in Finland since 1752.We also present for comparison a shorter dataset for the two species based on another kind of data source namely the Finnish National Phenological Network (Kubin et.al. 2007) organized by the Finnish Forest Research Institute (Metla) in 1996.

Material and methods

Most observations in the long-term phenological Finnish dataset refer to so-called core species which comprise 41 species of plants and fungi and 30 animal species. But, the observers are encouraged to record other species, too. The participants are provided with instructions on how to make observations in the field. For the details see e.g. (Terhivuo 1996). In this paper we present the data on the beginning of flowering in the rowan (*Sorbus aucuparia* L.) and the bird cherry (*Prunus padus* L.) in Finland. We chose the two plants because they represent species with great numbers of observations covering well the study period. Moreover, they are well-known plants among laymen and distributed all over Finland, Scandinavia and most parts of Europe.

Finland is a long country in south-north direction and the delay in the onset of a given phenological phenomenon may be weeks. To even out this difference we divided the geographical area of Finland into four zones based on the Finnish national uniform grid (27° E) system. viz. zone A (c. 59° 30'- 61° 00' E), B (c. 61° 00'-63° 00' E), C (c. 63° 00'-66° 00' E) and D (c. 66° 00'-69° 00' E) (Fig. 1). Due to the uniformity of the grid squares making the basis for the grid system adopted the zones only roughly parallel to geographical latitudes (Heikinheimo & Raatikainen 1971). For the distribution of the observation sites and numbers of observations in the four zones consult Fig. 1 and Table 1. The participants were asked to make their observations from the same area, pay attention to individuals that live in their normal habitats and if possible observe the same plants individuals year after year.

In any large phenological dataset such as the present one there are observations that in a frequency distribution diagram over all the observations seemingly are outliers i.e. uncertainties due to mistakes by the observer in writing up the dates of their observations or due to mistakes made during the process of digitalization. To minimize this source of error we rejected 0.5% of observations from each ends of the tails in the frequency distributions of the two species.

For comparison we adopted an independent dataset compiled by the Finnish National Phenological Network which is run by the Finnish Forest Research Institute (Metla) since 1997. In this survey phenological observa-

Tab. 1 – Median day (Md) for the start of flowering in rowan and bird cherry during the years 1752-2007 in zones A-D and in the whole country. N-tot refers to the total number of observations, Min-Max is the range of the median days. The corresponding parameters are also indicated for the years 1997-2008 based on data from Finland's national observation network.

***Tab. 1** - Giorno mediano (Md) per l'inizio della fioritura del sorbo degli uccellatori e del pado negli anni 1752-2007 nelle zone A-D (vedi Fig. 1) e nell'intera nazione. N-tot è il numero totale delle osservazioni, Min-Max è l'intervallo dei giorni mediani. Sono riportati anche i corrispondenti valori per gli anni 1997-2008, basati sui dati della rete nazionale di osservazione della Finlandia.*

Species	Zone	Ntot	Md	Min - Max
Rowan	A	2 053	160	131 - 193
Sorbus aucuparia	B	1 658	161	132 - 191
	C	862	167	132 - 197
	D	205	176	139 - 197
	Total	4 778	162	131 - 197
Bird Cherry	A	2 388	146	124 - 182
Prunus padus	B	1 776	148	124 - 182
	C	972	155	128 - 183
	D	194	167	139 - 184
	Total	5 330	149	124 - 184
Finlands national network				
Sorbus aucuparia		361	165	143 - 203
Prunus padus		361	151	129 - 205

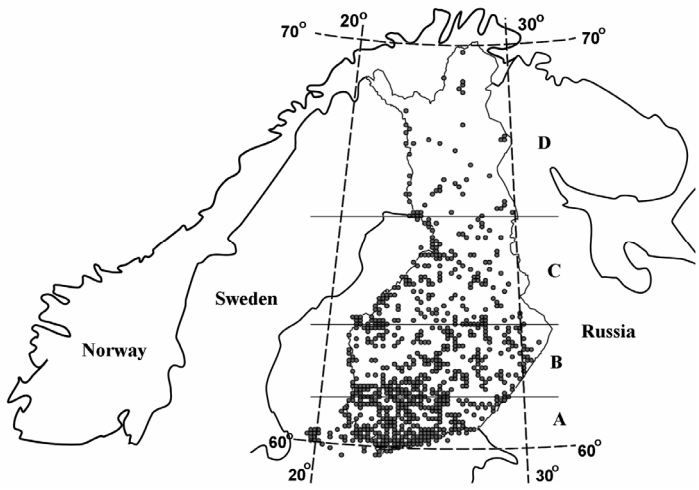

Fig. 1 - Localities for phenological data collection of rowan (*Sorbus aucuparia*) and bird cherry (*Prunus padus*) in Finland in 1753-2007.

***Fig. 1** - Località di raccolta di dati fenologici sul sorbo degli uccellatori (*Sorbus aucuparia*) e sul pado (*Prunus padus*) in Finlandia, nel periodo 1753-2007.*

tions are made by trained observers and the same tree individuals are observed at least twice a week. The observations in this network are given in Table 1. For additional information see Kubin et al. 2006, 2008.

As for statistics we applied SPSS programme package to perform linear regressions between annual medians and the observation years. In addition, box plot graphs were worked out. We also applied non-parametric statistics namely Mann-Kendall test and Sen´s slope estimates as indicated in Salmi *et al.* (2002). In our calculations Julian calendar days are given serial numbers so that January 1 = 1, January 2 = 2 and so on.

Results

Based on annual medians during years 1752-2007 the flowering of rowan appeared earlier at the rate of three

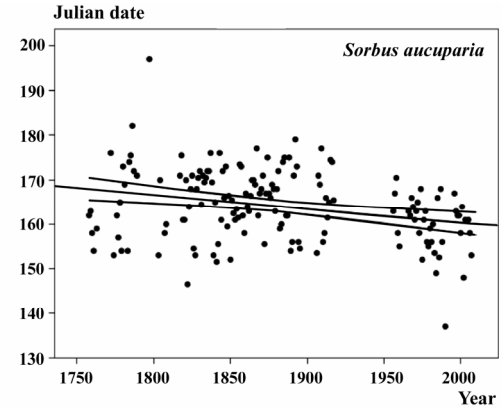

Fig. 2 - The start of flowering in rowan during the period of 1752-2007. **o** = median of annual observations. Regression line (-0.031x + 222.816) and its 95% confidence limits have been drawn into the figure. (R^2 = 0.074, p<0.001).

Fig. 2 *- L'inizio della fioritura del sorbo degli uccellatori nel periodo 1757-2007.* ***o*** *= mediana delle osservazioni annuali. Nella figura è stata tracciata la retta di regressione (-0.031x + 222.816) e il suo intervallo di confidenza al 95%. (R^2 = 0.074, p<0.001).*

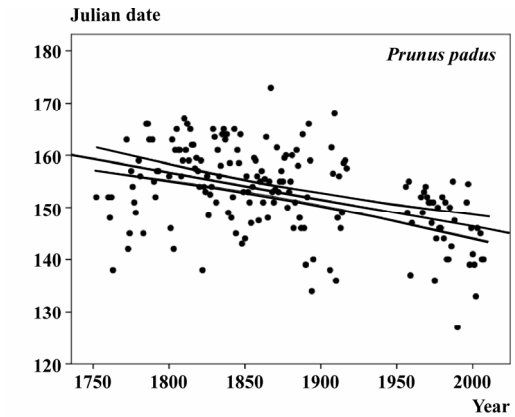

Fig. 4 - The timing of flowering in bird cherry during the period of 1752-2007. **o** = median of annual observations. Regression line (-0.052x + 250.537) and its 95% confidence limits have been drawn into the figure. (R^2 = 0.201, p<0.001)

Fig. 4 *- La fioritura del pado nel periodo 1757-2007.* ***o*** *= mediana delle osservazioni annuali. Nella figura è stata tracciata la retta di regressione (-0.052x + 250.537) e il suo intervallo di confidenza al 95%. (R^2 = 0.201, p<0.001).*

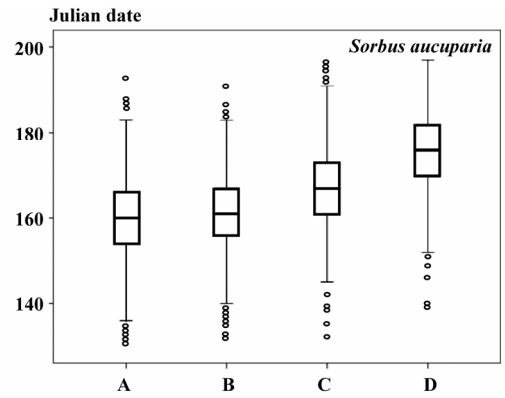

Fig. 3 - The start of flowering in rowan in zones A-D from the south (A) to the north (D) as shown by box plots. Inside the box there are 50% of the observations and the median line. The variation in the material represented by the line segment is 1.5 times the length of the box in both directions. o = year median outside the line segment. For the zones see Fig. 1.

Fig. 3 *- L'inizio della fioritura del sorbo degli uccellatori nelle zone A-D dal Sud (A) al Nord (D) mostrato con diagrammi a scatola. La scatola contiene il 50% delle osservazioni e la linea mediana. La variazione dei dati rappresentata dal segmento di retta è 1,5 volte la lunghezza della scatola in entrambe le direzioni. o = mediana dell'anno fuori dal segmento di retta. Per le zone vedi Fig. 1.*

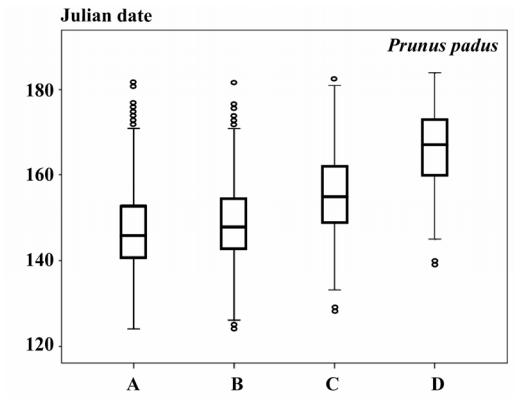

Fig. 5 - The timing of flowering in bird cherry in zones A-D from the south (A) to the north (D) as indicated by box plots. Inside the box there are 50% of the observations and the median line. The variation in the material represented by the line segment is 1.5 times the length of the box in both directions. o = year median outside the line segment. For the zones see Fig. 1.

Fig. 5 *- La fioritura del pado nelle zone A-D dal Sud (A) al Nord (D) mostrata con diagrammi a scatola. La scatola contiene il 50% delle osservazioni e la linea mediana. La variazione dei dati rappresentata dal segmento di retta è 1,5 volte la lunghezza della scatola in entrambe le direzioni. o= mediana dell'anno fuori dal segmento di retta. Per le zone vedi Fig. 1.*

days per 100 years in Finland (Fig. 2). However, due to the great deviation of some years, the regression was weak and the slope small, -0.031. The median day for the onset of flowering was day 162, i.e. 11th of June and the range of medians was 131-197. The median day increased by 16 days when moving from region A northwards to region D (Figs. 1, 3, Table 1). We also calculated z = -2.94178 (Mann-Kendall test) ($p<0.01$) and Sen´s equation y = -0.02941 (x-1752) + 169.23, where 1752 is the first year of the observation period for rowan . Based on the latter equation we can estimate that the rate of change is 2.9 days / century. This is almost the same as indicated by the parametric linear correlation shown in Fig. 2.

Bird cherry starts flowering earlier than rowan as shown if comparing Figs. 2 and 4. During years 1752-2007 bird cherry has come into earlier blooming at the rate of five days per 100 years (Fig. 4). The slope of the regression was a bit greater (-0.052) than that of rowan. But, the deviation between the years was great. The median day for the start of flowering was day 149, i.e. 30th of May, and the range of medians in the entire material was 124-178. The onset of flowering was delayed when moving northwards from region A to region D by 21 days (Fig. 5, Table 1). Application of non-parametric Mann-Kendall test resulted z = 5.79642 ($p<0.001$) and Sen's equation was y = -0.05348 (x-1752) + 159.9627. Based on the latter equation the rate of change is 5.3 days / century. This is much the same as indicated by the linear regression in Fig. 4.

In rowan the material provided by Finland's national phenological network (Fig. 6) for the period 1997-2008 indicates no clear-cut differences in comparison to the same period in Fig. 2. The median day of this observation period was three days later than the overall median of the period 1752-2007 (Table 1).

In the bird cherry the median for flowering was day 151 in the material covering the period 1997-2008 is two days later than the median for the long-term observation period. In general , the material is quite analogous with the long-time observation period unless the late flowering in 2008 (Fig. 7) is taken into account.

Discussion

In the Finnish long-term datasets the overall trends show an earlier burst of flowering.. This is in agreement with the corresponding datasets from many other European countries presented in e.g. the COST Action 725 Workshop in ROME in November 6-7, 2008 and published now in this forum. As counted from the regression lines (Figs, 2 and 4) the rate of change is three days/ century for rowan and five days/century for bird cherry, respectively.

Dissimilar responses between the two species may be attributed to the impact of many joint factors rather than any single factor. For instance, the species are genetically and physiologically dissimilar and they do not share same requirements as for biotic and abiotic factors in the habitat they live.

No doubt, there are inaccuracies in the datasets due to factors such as dissimilar activity patterns between persons making observations in the field. There may be mistakes in writing up the dates for the onset a phenomen in the field or in digitalizing the dates. By using annual medians instead of annual means the impact such biases especially in years with low numbers of observations can be decreased at least to some extend. Rejection of clear-cut outliers did not cause any systematic error in calculations. In both species decreasing trends were obvious no matter whether outliers were considered or not.

Another noteworthy point in the long-term dataset is that the turn-over rate of observers participating the surveys is nowadays higher (10-20% /year) than in early phases of it. As an example we may mention that Mrs. Norden-

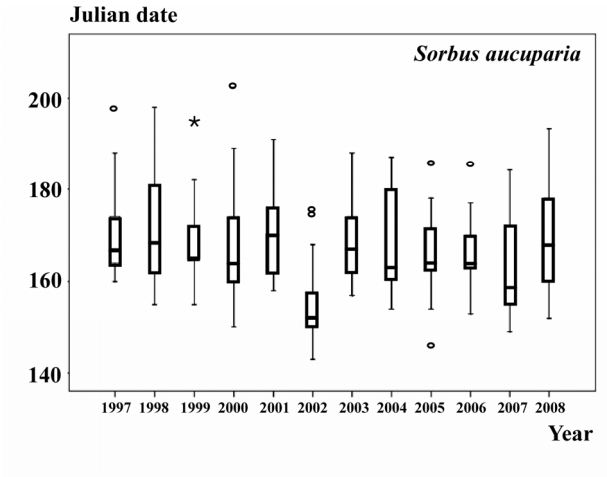

Fig.6 - The timing of flowering in rowan based on the material by Finland's national phenological observation network in 1997-2008. For details consult the legend to Fig 3.

Fig. 6 *- La fioritura del sorbo degli uccellatori nel periodo 1997-2008, basata sul materiale della rete nazionale finlandese di osservazione fenologica. Per i dettagli vedi la legenda di Fig. 3*

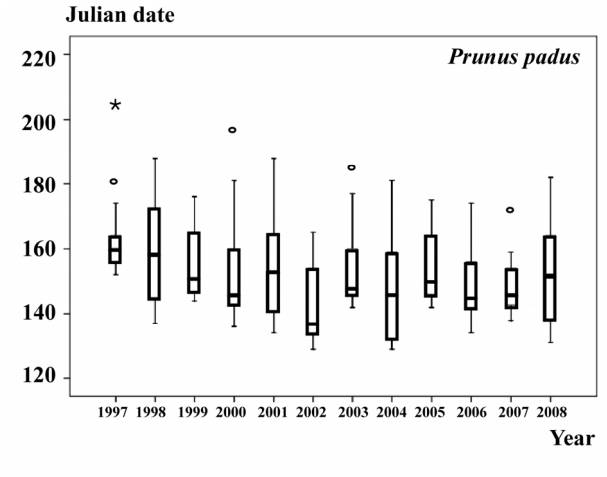

Fig. 7 - The timing of flowering in bird cherry based on the material provided by Finland's national phenological observation network in 1997-2008. For details consult the legend to Fig. 3.

Fig. 7 *- La fioritura del pado nel periodo 1997-2008, basata sul materiale fornito dalla rete nazionale finlandese di osservazione fenologica. Per i dettagli vedi la legenda di Fig. 3*

streng made observations in the same place in Saarijärvi (Central Finland) from 1907 to 1950 (Häkkinen 1999). There is, however, no indication that the differences in the turnover rate of observers would lead to any systematic error in the dataset and therefore we have considered this bias to be negligible and that it represents a kind of background noise always present in large phenological datasets based on field observations.

Our data (Figs. 2 and 4) indicates an earlier start of flowering in the two species today than about 250 years ago.

The flowering of bird cherry taking place earlier than that of rowan (Figs, 2 and 4) may be taken as an indication of its greater sensitivity to lower cumulative air temperature sums than rowan. Moreover, the rate of change in the onset of blooming was greater in bird cherry than in rowan. Perhaps this can be attributed to a more sensitive reaction norm in bird cherry than in rowan on increases in cumulative temperature sums of springtime. On the other hand, the difference of medians in zones A and D is only 16 days in rowan whereas in bird cherry it is 21 days. Seemingly rowan after having started flowering in the south can finish it in the north during a shorter period than bird cherry.

The wide deviations between the years and the shortness of the time series (1997-2008) provided by the observation network may be responsible for the slightly higher overall medians in comparison to that of the longer observation period.

Conclusions

We conclude that the blooming of rowan and bird cherry starts nowadays earlier than e.g. one or two hundreds of years ago. The rate of decrease based on the present series of median dates is three days/ century in rowan and five days/ century in bird cherry. We want to stress the importance of carrying on "old type" phenological observations in the field but we also see the necessity of the adoption of more precise methods based on permanent network of observation sites and on the same individuals of test plants.

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