OLD NORWEGIAN PHENODATA SERIES IN RELATION TO RECENT ONES

LUNGHE SERIE STORICHE FENOLOGICHE NORVEGESI MESSE IN RELAZIONE CON SERIE PIÙ RECENTI

Frans-Emil Wielgolaski

University of Oslo, Dept. of Biology, PoB 1066 Blindern, 0316 Oslo, Norway
E-mail: f.e.wielgolaski@bio.uio.no, tel. +47 22854627

Received 15/12/2008 – Accepted 16/02/2009

Abstract
Observations in Norwegian plant phenology through the last 150 years are analyzed. Generally, earlier first flowering is found in the 1900’s than in the mid 1800’s, in accordance with increasing temperature since the “Little Ice Age”. However, throughout the years 1928-1977 no clear phenological trends are found, although there was a very early flowering of most plants in the beginning of the 1930’s (at the high summer temperatures during that period) and about 1950, while late particularly in the mid 1960’s and from the mid 1970’s (at lower temperatures). Generally, since the mid 1990’s, flowering (as well as bud burst of deciduous trees) has been earlier; but in some districts, maybe a little later again during the last couple of years, in accordance with a general 10-15 year oscillation of phenology found by smoothing the curves of flowering dates by Gaussian filtering.

Keywords: Plant phenology, Temperature, Bud burst, Flowering, Gaussian filtering.

Introduction
Norway is a long and narrow country, covering more than 13° of latitude (from 58°N to more than 71°N) but is at the narrowest not more than a few km wide from the innermost bottom fjord at approx. 68°N to the Swedish border (Fig.1). The mountains rise abruptly from the western coast and the many fjords to more than 2000m elevation. In the East of the mainly N-S mountain chains, however, there is a gentle lowering of the elevation again.

About 6000 years ago the mean temperature in Norway was 1-3°C higher than today. Then heat demanding deciduous trees invaded many Norwegian lowlands, particularly in southern Norway (e.g. elm, linden, hazel and oak), and the tree line was considerably higher than today. However, during the “Little Ice Age” from about 600 to about 150 years ago (Fig.2), temperature was very low, precipitation abundant, and the tree line even lower than recently. The tree line today is at about 500m a.s.l. in the far southwest of Norway, increasing to 1300m elevation in central mountains and decreasing to approximately zero near the sea north of 71°N (Aas and Faarland, 2001).

Both climatic and phenologic variations thus are strong within the country, e.g. the sun remain above the horizon for 24 hours a day during summer in the north of the Arctic Circle. Unfortunately, there are no continuous phenomenological scientific observations carried out through centuries in any part of Norway. Scattered data, however, are found from various parts of the country from mid 1800’s (Fig.1). Most phenodata were collected in the mid 1900’s in the Lauscher and Printz network (Lauscher and Lauscher, 1990). This network lasted from 1928 to 1977 and covered several phenophases of plants and animals located in stations all over the country, however mostly in the southern lowland district (Fig.1). Today there are data available on spring phenology of birch at about 20 stations monitored by the Norwegian Meteorological Institute, from two IPG (International Phenological Garden) sites, and from two fruit research stations (Wielgolaski and Måge, 2008).

Material and methods
Phenological variation on several species for one phenophase and at one site might be studied and presented as in Klaveness and Wielgolaski, 1996. More common are studies of phenological trends in one or more species at several sites, either by smoothing the annual variation
using linear trends (e.g. Shutova et al., 2006) or e.g. by Gaussian filtering technique (Nordli et al. 2008a). Examples on various methods used are shown on Norwegian plant phenological material in the present paper. Quality of Norwegian data from the 1900’s is discussed by Lauscher et al. (1955), also from the 1800’s by Klaveness and Wielgolaski (1996). Some mean first flowering dates (mFFD) of the oldest series with standard deviations and confidence interval (C.I.) are given in Table 1 for some plants at Land (inland southern Norway), Christiania (now Oslo) (southeastern coast) and a few species at Nyborg (coastal northeasternmost Norway). The quality of more recent data is discussed by Nordli et al. (2008a).
Results and discussion
In Norway, from mid 1800’s to mid 1900’s, mean temperatures in many lowland districts have increased by the order of 1.0°C (e.g. Førland, 1993). That explains the often earlier mFFD found in the mid 1900’s than in mid 1800’s at the southeastern lowland site Christiania (Fig. 3, left) but particularly at the coastal, extreme northern site Nyborg (Fig. 3, middle), where the change in flowering was found to be more than one month on the same species. At the last site, however, only 11 plant species were common to the series of Sommerfelt (1885) and that of Lauscher et al. (1959, 1978) from six stations east of 24°E and north of 70°N. In Christiania (Oslo) there were several similar plant species observed both in the 1800’s (Schübeler, 1885) and in the 1900’s (Lauscher et al., 1959, 1978). If we look at plants common to the two observation series, it is found that most of the species show earlier mFFD in the mid 1900’s than in mid 1800’s, nearly half of the series even with differences in mFFD>2C.I. (Table 2). The change is clearest in mid and late spring - early summer (May-June). Then the difference in flowering is calculated to be of the order of two weeks, which is somewhat more than the average of 2-5 days earlier flowering in the 1900’s concluded by Lauscher et al. (1955) for various species in Oslo.

At the third Norwegian site with phenological observations both from the mid 1800’s and 1900’s, the southern inland site Land at somewhat higher elevation ca. 300m (Fig. 3, right), there were small changes in mFFD of various species through the period, maybe even a slight delay in flowering in the most recent period. This might be seen as a result of a small increment in precipitation falling as snow in winter and resulting in later snow melt and cold water and air streams in the valleys. A similar delay in spring was observed by satellite in montaneous and in northeastern districts of Norway during
the last two decades of the previous century (e.g. Wielgolaski and Karlsen, 2007), probably mainly due to more precipitation falling as snow melting late in spring. In the 50 year study of plant phenological observations in Norway through 1928-1977 (Lauscher and Lauscher, 1990), very few general trends could be found, as seen e.g. for the time of first flowering of *Convallaria majalis* (Fig.4). However, by smoothing the curves of flowering dates by Gaussian filtering (Nordli et al. 2008a), it is obvious that there are clear 10-15 year fluctuations in the earliness within the 50 year period. It is well known that summer temperatures in southern Norway were high in the early 1930’s (e.g. Førland 1993), which were reflected by early flowering in *Convallaria* at several lowland sites in southern Norway. Similarly, it has been observed in other studies that the alpine tree line increased in that period (Kullman 1979). Early flowering was also observed for *Convallaria* by the end of the 1940’s and to some degree in the beginning of the 1960’s (and weakly in the beginning of 1970’s), while from then on to the end of the study period (1977) flowering was later. Kullman (1979) found that seedling establishment of birch came to a halt in the late 1950 at the tree line, due to a less favourable climate. The 10-15 year fluctuations in plant phenological earliness may be seen as a result of variations in the sun radiation, but it has not been the scope of this study to look further into that. However, the fluctuations clearly show the need for long phenological studies before conclusions are drawn on linear trends in a period. Opposite conclusions are drawn

**Fig. 4** - First flowering of *Convallaria majalis* 1928-1977 at some Norwegian lowland sites. Ordinate: Nos. of days from January 1 (Julian days).

**Fig. 5** - First bud burst at the Norwegian International Phenological Garden sites through approx. the last 40 years (abscissa). Ordinate: Nos. of days from January 1 (Julian days). Fana (strongly western oceanic site) and Kvithamar (site in the fjord district, central Norway). Unbroken line=Betula, long dashed line=Picea abies, short dashed line=Larix decidua, dotted line=Populus tremula, narrow white broken line=Fagus. (Redrawn from Nordli et al., 2008b).

**Fig. 6** - First flowering of fruit trees at two Norwegian fruit research stations, Njøs (in oceanic fjord district) through approximately the last 80 years and Ås (in more continental southeastern district) through last 50 years. Ordinate as in Fig. 5. Unbroken line=apple, dashed line=plum, dotted line=pear, narrow white broken line=sweet cherry. (Redrawn from Nordli et al., 2008b).
from observations starting in the mid 1960’s and continuing today (Nordli et al., 2008a). Temperatures have clearly increased in the last decades, and bud burst of various tree species have been earlier through the same period; although shorter, 10-15 year, fluctuations are found both at a Norwegian strongly oceanic station (Fana 60°N) and a central Norwegian station (Kvithamar 63°30’N) (Fig.5). In comparable years early bud burst has been seen in the same periods as early flowering of Convalaria (e.g. in the early 1970’s). This was also observed in first flowering of different fruit trees both at a Norwegian western, relative oceanic fjord site (Njøs) and at a more continental southeastern site (Ås) with lower winter temperatures (Fig.6).

By comparing the timing of phenophases in figures 5-6 during the last years, an interesting difference may be observed. At the three more oceanic Norwegian sites Fana, Njøs and Kvithamar, there is a tendency to later phenophases in 2006-2007 following the expected or “normal” 10-15 year oscillations. This, however, is not observed at the most continental and winter cold site Ås, which showed very early fruit tree flowering in these years (Nordli et al., 2008b). This might be seen as plant physiological adaptations to climate changes. Many trees growing in a cold climate need a physiological chilling period before they can start new development in spring by increasing temperature. The most effective chilling temperatures are found to be between 4 and 9°C (Heide and Prestrud, 2005), while temperatures below 0°C are found to be nearly inactive (Powell, 1986).

At the more oceanic sites with relative mild winters through several years, the period of active chilling was fulfilled also before the last temperature increase. Then new plant development in spring occurred as soon as temperature rose but followed the “normal” 10-15 year oscillations and, therefore, with somewhat later flowering again in the most recent years. At Ås, however, although increasing temperature in winter even there, the period of temperature above the limit for physiological chilling has not been fulfilled yet, or just recently. A hypothesis may be that this causes a different influence on the timing of phenophases than found at the other, more oceanic sites.

Later flowering of e.g. Vaccinium myrtillus (Fig.7) are observed at higher elevated sites (Røros and Røldal) and in northern regions of Norway (Jarfjord) due to lower summer temperatures than at lower elevated southern sites (the rest of the sites in Fig.7, although the Ask site is at somewhat higher elevation (78m) than Kristiansand, Helle and Dilling). The shape of the curves, however, is more or less similar at all lowland stations, except for the extreme northeasternmost station Jarfjord. This site close to the northern Russian border is not so strongly influenced by the NAO as the rest of Norway. Probably that is the main reason why the fluctuation in time of the phenophase at Jarfjord partly differs from those at the other stations studied.

Conclusions

1. There have been generally earlier observations of most plant phenophases all over Norway since the end of the “Little Ice Age” around 1850, mainly due to higher temperatures.
2. At higher elevations and in North-east of the country, however, a delay has been observed partly in spring phenophases during the period, probably because of higher precipitation giving later snow melt in the generally lower winter temperatures in these districts than in the southern lowlands.
3. In shorter periods (e.g. 1928-1977) no general linear phenological trends are observed. Because of 10-15 year oscillations in timing of phases found by smoothing phenological curves by Gaussian filtering, it is very important when the studies start and end, i.e. when in the short fluctuations the studies are carried out.
4. Recently, during the last about 20 years, generally extreme early phenophases have been seen, due to the temperature increment by Climate change. However, many cold region plants need a period of physiological chilling during winter (at temperatures in the order of 4-9°C). If such chilling is not fulfilled, it may influence the phenophases at increasing temperatures differently in districts with cold winters and in more oceanic districts.
References


