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DISCUSSION ON RELIABLE PHENOLOGICAL OBSERVATIONS AS A PRECONDITION FOR SEASONAL AND CLIMATOLOGICAL HYDROMETEOROLOGICAL FORECASTS

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Introduction

Rudiments of phenology appeared in high antiquity when people began to memorize the recurring natural phenomena and associate them with other ones, e.g., with the weather and change of climate elements. There are proverbs and sayings in folklore, which are actually, long- or short-term or even seasonal weather forecasts. The science of phenology has derived from the juncture of meteorology, biology and geography. Namely in the junction of various sciences the greatest discoveries were made in the last fifty years.

The father of Lithuanian phenology Stasys Nacevičius started regular observations of natural seasonal phenomena in Dotnuva (Middle Lithuania) in the first half of the 20th century. He also created a network of phenological observations operating within a unified programme, affiliated and exchanged information with the European Centre of Phenological Observations in London.

After World War II, many Lithuanian agrometeorologists, climatologists, foresters and dendrologists developed the general and applied phenology (Taikomoji…, 1983) based on S. Nacevičius' scientific heritage. Yet his attempts to use the data of phenological observations for seasonal weather forecast have remained unappreciated. This is worth mentioning as meteorologists have not yet developed reliable methods for a longer than 5–7 days weather forecast.

After the restoration of Lithuania's independence, phenology is on the decline. The number of observation stations has reduced considerably. The data of the remaining stations is not systematized and inaccessible to specialists of related sciences and students due to interdepartmental barriers. The newly established Society of Phenologists make every effort to develop an amateur network of observations (mostly in schools). Yet it will take some time before the data collected is used for serious scientific purposes.

The present work is based on a limited and far from newest observation data. It is designed for attracting attention of Lithuanian scientific structures to this branch of science. It is necessary to allocate sufficient means for phenological observations and to create a legal basis for use of phenological observation data by scientific research.

1. Data and Methodology

Phenological indicators of different seasons and their stages as well as data of phenological observations in different regions of Lithuania were obtained from the earlier published works on phenology (Nacevičius, 1975; Kulienė, Tomkus, 1990) and from the Lithuanian Hydrometeorological Service. They are far from being sufficient for exhaustive explanation of correlation between phenological and cosmological as well as hydrometeorological parameters but they can show promising results in this field of neighbouring sciences if the necessary steps are taken. The long-term data on solar activity (Wolf indices) are taken from the open files of the Zűrich Observatory in Internet.

From the phenological and phenoclimatic point of view, the seasons are sub-divided into stages mostly based on S. Nacevičius‘ scheme (it is not perfect in terms of terminology). Table presents the stages of seasons and phenoindicators marking their beginning.

Table. Stages of seasons and phenoindicators marking their beginning (according to S. Nacevičius and others).

Season	Stage I	Stage II	Stage III
Spring	Early spring European filbert, grey alder and coltsfoot come into bloom	Spring proper Goat willow come into bloom	Late spring Bird cherry come into leaf
Summer	Early summer Peony come into bloom	Midsummer	Late summer
Autumn	Golden fall Yellow leaves	Leaf fall Trees shed leaves	Prewinter time Bare trees
Winter	Early winter Ponds freeze over	Winter proper Rivers freeze over	Prespring time Snow melts

2. Main Phenological Parameters Applicable for Hydrometeorological Forecasts

It is already possible to distinguish the trends of the employment of phenological data for seasonal weather forecasts. First, based on the long-term pattern of phenoindicators of early spring (for example, coltsfoot coming into bloom in Dotnuva in 1961–1991) it is possible to predict an approximate date of the beginning of vegetation period for a few coming years (Fig. 1). It is known that the beginning of vegetation period in Lithuania varies considerably – from the end of January until the beginning of April. However, even the knowledge of the beginning of vegetation period (late, proper or late spring) can be of practical use for not only farmers but also for foresters, beekeepers, resort researchers, and managers of tourism industry. European filbert (*Corylus avellana* = *c*), grey alder (*Alnus incana* = *a*) and coltsfoot (*Tussilago farfara* = *t*) are early spring phenoindicators whose blooming approximately coincides with the beginning of vegetation. Thus, observations of their (or at least one of them) blooming time may be of use. The sequence of coming into bloom of these phenoindicators is especially interesting and important. The term **interception** has been applied to derangement of a long-term (dominant) sequence of vegetative events of matching phenoindicators. However, for convenience the term should be applied to vegetative combinations (variation of the date of their vegetative condition) of any phenoindicators the more because any dominant combination tends to change in the course of time. It is useful to know the combinations of not only phenoindicators but zooindicators as well, for example the dates of return of cuckoos and swallows.

European filberts, grey alders and coltsfoot come into bloom almost at the same time in Lithuania but following a certain sequence. In springs when southern air mass transport is dominant, these phenoindicators come into bloom in the same sequence as in the Ukraine. European filberts are first to come into bloom. Grey alder and coltsfoot follow them. The first letters of the Latin names of these plants can write the following interception: *c-a-t*. When eastern continental air masses are more frequent in spring, the sequence of coming into bloom of these plants is different: *t-a-c* (it is typical of the middle part of European Russia). When at the end of winter the humid air mass from the North Atlantic visits Lithuania more frequently, the blooming sequence of the mentioned spring indicators is *a-c-t*. *A-t-c* interception characteristic of the Bay of Finland occurs under dominant northern winds. Other kinds of interceptions may occur in Lithuania (*c-t-a* and *t-c-a*) under the conditions of mixed flows of unstable atmospheric circulation. Analysis of the links between these interceptions and hydrometeorological conditions can be promising for weather forecasts

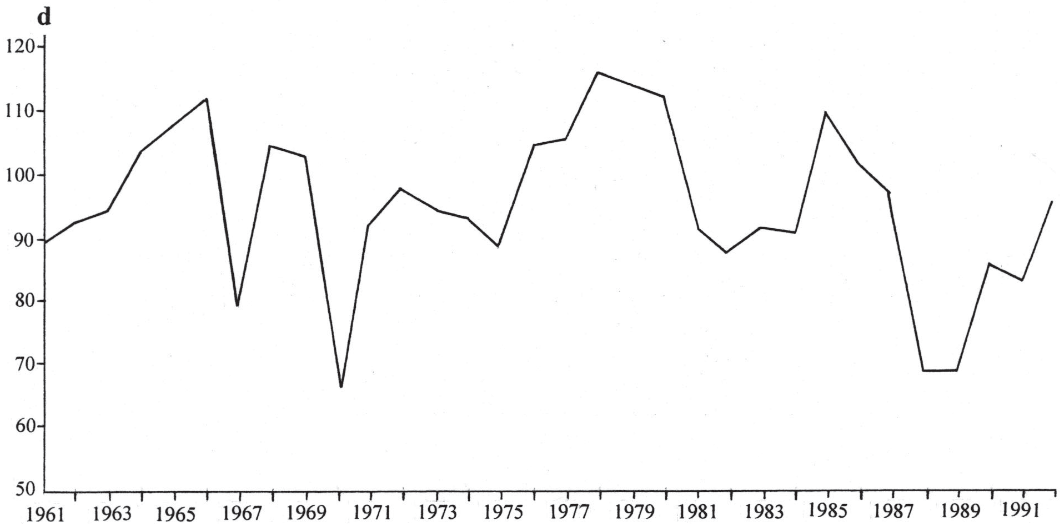

Fig. 1. Coltsfoot (*Tussilago farfara*) coming into bloom in Dotnuva 1961–1991.

for the rest of the season, summer and autumn. S. Nacevičius envisaged other important interceptions for weather forecast: combinations of coming into bloom of lilacs (*Syringa vulgaris*) and rowans (*Sorbus aucuparia*), as well as bird cherries (*Prunus padus*) and sour cherries (*Prunus cerasus*).

Based on interceptions and relations of different phases of phenoindicators with some cosmogenic (solar activity) and hydrometeorological phenomena as well as with the time-scale of agrotechnical works, S. Nacevičius made an attempt to predict frosts, probability and time of pests and optimal time-scales for various farming works. Unfortunately, no detailed description of his research, deeper analysis of the interaction between different factors or methods has been preserved. We have only conclusions and bare statements. His research was based on the data for 1922–1947. We know that the cycles of natural phenomena and their relations with cosmogenic driving forces may vary depending on the long-term variation stage of cosmogenic factors, for example on the cycles of solar activity (Дорман и др., 1987). Cycles of solar activity lasting for 200, 100, 22, and 11 years have been determined. In their different phases (e.g., increase or decline of amount of sunspots within the cycle, running number of 11 years cycle), the links between manifestations of nature cycles may markedly vary (this was not known in the times of S. Nacevičius).

3. Correlation between Phenological Parameters, Solar Activity and Seasonal Weather Conditions

S. Nacevičius determined the weather conditions during the vegetation period depending on the type of interception marking the beginning of spring. According to his data, *c-a-t* interception is dominant in Lithuania, i.e. spring is brought by southern flows. The year of this type of interception is expressive (S. Nacevičius' term), i.e. early. This means that not only spring is early but other phenological seasons as well. The probability of frosts in the third stage of early spring is low. Moreover, summer is warm and autumn is favourable for farm works.

The interception *a-c-t* shows the influence of the Atlantic Ocean. From the point of view of weather forecast, the spring of this type is unreliable as the year may either be depressive (late) or expressive and even mixed because some seasons may be early and others late. In such years, the north wrestles with the south. Spring drags on, summer is not very warm, sometimes even cool and rainy, and autumn varies. Detailed investigations of a longer sequence of years, perhaps, could help to determine some additional indices for forecasting.

When in spring Lithuania is under the influence of Eurasia, the phenoindicators come into bloom in the following order: *t-a-c*. All spring stages are late, the third one passing without frosts and as if in a rush. Summer comes on time. It is marked by continental hot weather conditions. Autumn is favourable for farm work.

The *a-t-c* interception is not very promising to farmers. It occurs in the Bay of Finland-type of year under the influence of northern flows. Spring is late, summer unstable (combat between the south and the north), and autumn is unfavourable for farmers.

The spring of the *c-t-a* type heralds a depressive year. Yet there are no frosts in spring proper and autumn is favourable for farm work.

Nacevičius noticed that the stability of the prognostic features of interceptions depends on the peculiarities of the cycles of solar activity. In years of maximum number of sunspots and high solar activity, the atmosphere is more susceptible to changes. The typical of interceptions weather conditions usually occur two years before the maximal solar activity and two years after the minimal solar activity, i.e. in the phases of increasing and decreasing solar activity. The probability of cold winters increases, when the number of sunspots is reducing. Winters are warm a few years after the minimal number of sunspots. Comprehensive investigations are necessary for specification of prognostic features of interceptions.

There is a distinct link between the long-term pattern of coming into bloom of the mentioned phenoindicators and cycles of solar activity (Fig. 2).

Astronomers can predict the cycles of solar activity rather precisely. Based on the link between phenoindicators and solar activity, it is possible to forecast the trend of the beginning of spring (early, late and normal) within one cycle. The links get disturbed when the cycle is changing.

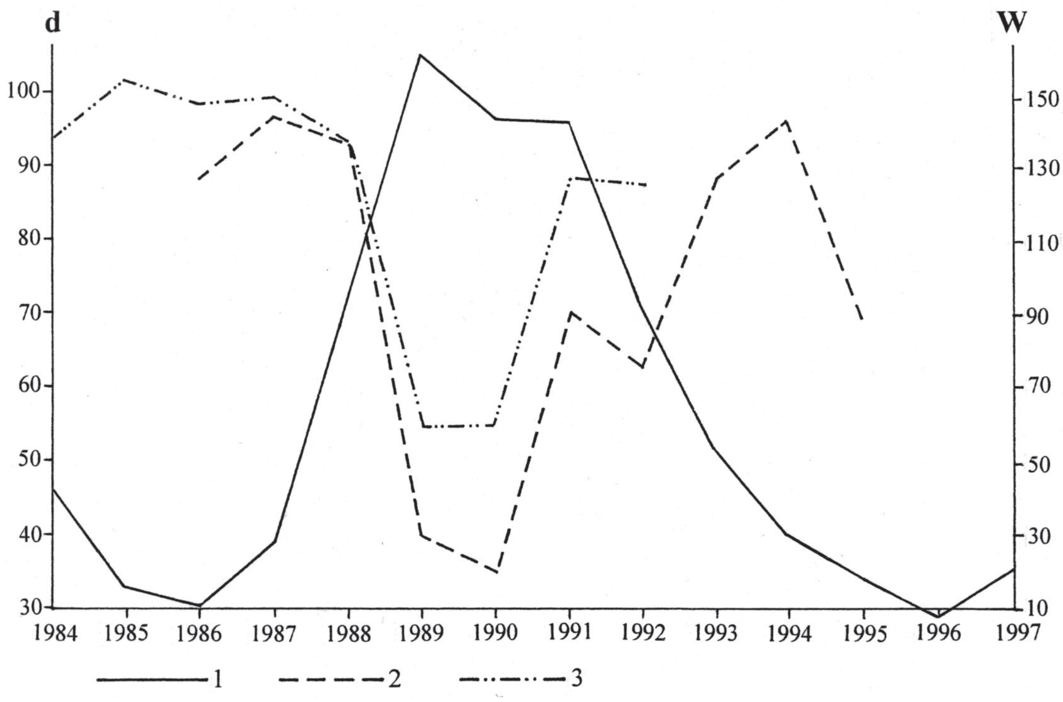

Fig. 2. Long-term pattern of phenoindicators and solar activity in Dotnuva: 1 – solar activity, 2 – grey alder, 3 – coltsfoot.

Attempts already have been made to relate the cycles of phenoindicators and solar activity with air temperature, precipitation, depth of freeze and other hydrometeorological dimensions (Schwartz, 1990). Methods of accurate hydrometeorological forecasts require comprehensive research based on reliable long-term hydrometeorological and phenological observations.

4. Reliable Phenological Data is a Prerequisite of Hydrometeorological Forecast

The Hydrometeorological Service has a fair network of observation stations supplied with modern equipment, qualified observers and own metrological survey. There is no reason to doubt the reliability of hydrometeorological data. The data is accessible to scientists and students. Unfortunately, this is not true about phenological observations. The data is scattered at different departments. Means and specialists are lacking for their generalization and systematization. The data is almost inaccessible to scientists and students who are unable to buy them. This order is a great disadvantage to the science of phenology, its practical application in particular. It is not expedient to use the amateur data because they are unreliable and may discredit good ideas (e.g. the method of interception). The incorrect data (a mistake of a few days suffices) of coming into bloom of phenoindicators change the interception. The seasonal forecast based on these data loses the scientific basis.

Conclusions

The phenological knowledge has been applied in agriculture, forestry and environmental science since long ago. For almost a hundred years, the long-term successions of phenological data sets have been an object of investigation of joint sciences. The present rather superficial analysis is designed to encourage seasonal hydrometeorological and long-term climatological forecasts based on phenoindicators, solar activity and hydrometeorological indices. This requires restoration of the network of phenological observations and accessibility of the data to scientists interested in the development of theoretical and applied phenology.

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Patikimi fenologiniai stebėjimai – prielaida sezoninei ir daugiametei hidrometeorologinei prognozei

Santrauka

Vien paprastas pavasario fenoindikatorių daugiametės eigos palyginimas su Saulės aktyvumo cikliškumu rodo, kad tarp jų egzistuoja neabejotinas ryšys. Praėjusio amžiaus viduryje į tai dėmesį atkreipė Lietuvos fenologijos tėvu vadinamas Stasys Nacevičius. Daugiausia dėmesio jis kreipė ankstyvojo pavasario fenoindikatorių intercepcijos – jų vyksmo tarpusavio eiliškumo – apraiškoms, jų ryšiui su tų metų vegetacijos laikotarpio ypatumais. Fenoindikatorių daugiametės kaitos ir Saulės aktyvumo cikliškumo koreliacijos pagrindu galima (kol kas kokybiškai) prognozuoti artimiausio dešimtmečio oro temperatūros, kritulių kiekio, sniegingumo, gal ir kitų klimato elementų vidutinius metinius ir sezonų rodiklius. Praėjus daugiau kaip pusei amžiaus atsirado naujų galimybių išplėtoti fenologijos taikymą hidrometeorologijoje, žemės ir miškų ūkyje, kurortologijoje ir kitur, juolab kad plečiasi ir astronomų žinios apie Saulės aktyvumą bei kitus heliogeofizinius veiksnius. Tačiau galimybės fenologijos mokslo plėtrai Lietuvoje prastėja: labai sumažėjo stebėjimo punktų tinklas, stebėjimų duomenis kaupiančios žinybos nepajėgia jų apibendrinti, o suinteresuotiems kitų įstaigų mokslininkams ši nepaprastai įdomi ir svarbi informacija neprieinama, jos negali gauti net studentai savo kursiniams, bakalauriniams darbams.