DENDROBIOLOGY
2005, vol. 53, 3–10

Leszek Bednorz, Agnieszka Urbaniak

Phenology of the wild service tree (*Sorbus torminalis* (L.) Crantz) in Poznań and Wielkopolski National Park

Received: 22 September 2004, Accepted: 02 December 2004

Abstract: In this paper the results of the 3-year observations (2001–2003) of seasonal rhythm of *S. torminalis* trees growing in Poznań in Dendrological Garden of Agricultural University and in forests of Wielkopolski National Park are presented. The observations included the course of leaf development, leaf coloration and leaf fall as well as flowering, fruit ripening and fall. Sixteen phenophases were taken into account. The differences in timing and duration of *S. torminalis* phenophases from year to year, between two sites and among trees within the same site are pointed out and discussed.

Additional key words: seasonal rhythm, climate factors, trees, *Rosaceae*

Address: L. Bednorz, A. Urbaniak, August Cieszkowski Agricultural University, Department of Botany, Wojska Polskiego 71c, Pl 60-625 Poznań, Poland, e-mail: lbednorz@au.poznan.pl

Introduction

Sorbus torminalis (L.) Crantz (*Rosaceae*) is a scattered temperate forest tree species. The species is native to Europe, Asia Minor, Caucasus and north-western Africa. In Poland *S. torminalis* grows only in western and southern part of the country and its range reaches there north-eastern limits (Browicz and Gostyńska-Jakuszewska 1966). The wild service tree is fully protected as a species in Poland (Rozporządzenie... 2004) and is considered to be rare and endangered one (Stecki 1950; Olaczek 1976; Pacyniak 1991; Żukowski and Jackowiak 1995; Boratyński and Barzdajn 1998). It is also a decorative tree species but very rarely planted in city greens.

The objective of carrying out the phenological observations is qualification of seasonal rhythm of plants and, in case of alien species, also their adaptation abilities. The start and duration of phenophases depend on climatic factors, biotope properties, competition between individuals and, of course, autorhythmicity of the species.

Phenological observations of *Sorbus* species were carried out in Kórnik (Chylarecki and Straus 1968), Poznań (Łukasiewicz 1978), and Szczecin (Nowakowska 2000), but they did not include *S. torminalis*. The aim of the present study was to get knowledge of seasonal rhythm of *S. torminalis* trees growing at two different locations, in urban area of Poznań and forests of Wielkopolski National Park. Another purpose of the study was to establish whether the start and duration of successive phenophases are synchronised with phenological seasons of the year and climatic factors, or whether they depend primarily on the autorhythmicity of the tree. The observations included the course of leaf development, leaf coloration and leaf fall as well as flowering, fruit ripening and fall.

Material and methods

Observations were carried out in the years 2001–2003 on two different sites, an artificial one in Dendrological Garden of Agricultural University (OD) in Poznań and natural one in Wielkopolski National Park (WPN). The site in OD (16°55'E, 52°25'N) is located in the southern slope of the valley of Bogdanka. The trees grow in half shade, on fresh and fertile soils and the competition from other species is slight. The site in WPN (16°49'E, 52°16'N) is located in Jeziory Conservation District, forest compartment 82j. The observed wild service trees, grow in deciduous fresh forest of *Galio sylvatici-Carpinatum* association, on soils lessivés, which is typical habitat for the species. The competition from other species is considerable and light conditions are rather poor. The distance between two sites is about 20 km. Four individuals on each site were observed at 2–7 days intervals from March to December (–January). All trees were about the same age (a few dozens of years) and size (diameter at the breast height 12–18 cm, height 8–13 m), and comparable good salubrity.

The methods of the study as well as the way of presentation of the results (phenological spectra) were adopted after Nowakowska (2000) and Łukasiewicz (1984) with some minor modification. The following phenological phases were observed:

l_1 – the beginning of bud break (green part of leaf at the bud apex is visible),
l_2 – the beginning of foliation (about 5–10% of leaves in the crown are being half-opened),
l_3 – full of foliation (more than 50% of leaves in the crown are half-opened),
l_4 – the beginning of leaf coloration (about 5–10% of leaves have changed their colour),
l_5 – full of leaf coloration (about 50% of leaves have changed their colour),
l_6 – the beginning of leaf fall (about 5–10% of leaves have fallen down),
l_7 – full of leaf fall (about 50% of leaves have fallen down),
l_8 – the end of leaf fall (about 90–95% of leaves have fallen down),
k_1 – the beginning of flowering (about 10% of flowers in the crown are opened),
k_2 – the beginning of full flowering (about 25% of flowers in the crown are opened),
k_3 – the end of full flowering (more than 50% of flowers in the crown are out of bloom),
k_4 – the end of flowering (about 90–95% of flowers in the crown are out of bloom),
o_1 – the beginning of fruit ripening (about 10% of fruits in the crown are being overcoloured),
o_2 – the full of fruit ripening (more than 50% fruits in the crown have the colour of ripe ones),
o_3 – the beginning of fruit fall (more than 10% of fruits have fallen down),
o_4 – the end of fruit fall (about 10% of fruits have remained in the crown or all have fallen down).

The results of phenological observations are presented in table 4 and graphic spectra for all the examined trees (group spectra) in figures 2–3. Explanations to figures 2–3 are shown in figure 1. The height of group spectra depends on number of trees with the same phenophase timing. Line refractions on spectra refer to number of trees with the same time of phenophase start.

Meteorological data (air temperature and precipitation for the years 2001–2003) come from the weather station of the Institute of Meteorology and Water Management (IMGW) Poznań-Ławica and automatic meteorological station of the Ecological Station of Adam Mickiewicz University at Jeziory (WPN – about 1 km from observation site). Dates of phenological seasons in Dendrological Garden were determined on the basis of observations of indicator plants (Kluza-Wieloch M. and Zientarska A. – unpublished data).

Meteorological data and phenological seasons for the years 2001–2003

Since the start and duration of phenophases depend on climatic factors, air temperature and precipitation for the years 2001–2003 were analysed at a background of long-time (1951–1980) data sets from Poznań-Ławica weather station (Tables 1, 2). Because precipitation data from Jeziory were not complete, they were not presented in the study.

All three years of phenological observations were warmer than usual. The warmest was 2002 with mean temperature of the year 9.8°C (it was also the wettest year), followed by cold winter of 2002–2003. In 2003 the phenological early spring came more than one month later than in previous two years, but until phenological spring start, the differences between subsequent years were almost equalised (Table 3). November and especially December 2003 were unseasonably warm, so that phenological winter did not start before January 4th the following year. The first autumn frost occurred in 2002 at the end of September and in 2001 and 2003 in the second half of October. Annual accumulated precipitation was higher than normal in 2001 and particularly in 2002. The next year – 2003 was extremely dry with only 330.6 mm of precipitation (Table 2). It is worth to notice that one third of annual precipitation that year fell in only one month – July; in February, May and August accumulated precipitation were below 10 mm. For some phenological events, such as leaf and fruit fall the wind might also be an important climatic factor.

Table 1. Mean temperature per day (°C) – Poznań-Ławica and Jeziory stations

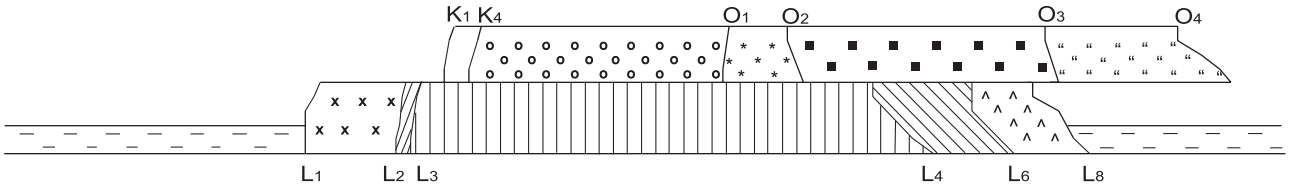
Years	Months												Mean of years
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
						Poznań-Ławica							
2001	–0.1	0.7	2.6	8.0	14.4	15.1	19.9	19.8	12.3	12.3	3.2	–1.6	8.9
2002	0.8	4.0	5.0	8.8	16.8	18.0	20.3	21.5	14.2	7.7	4.3	–3.6	9.8
2003	–1.7	–3.5	3.0	8.2	15.7	19.0	19.5	19.4	14.7	5.8	5.6	1.9	9.0
1951–80	–2.2	–1.4	2.1	7.4	12.7	17.0	18.0	17.3	13.4	8.5	3.7	–0.1	8.0
						Jeziory							
2001	–0.3	0.5	2.3	8.2	14.5	14.8	19.5	18.7	12.3	12.1	3.3	–1.6	8.7
2002	0.6	3.9	4.5	8.9	17.3	18.7	20.0	20.5	13.6	7.4	3.8	–3.9	9.6
2003	–2.2	–3.6	2.4	7.9	14.6	17.7	18.6	18.8	14.1	5.2	4.8	1.2	8.3

Table 2. Accumulated precipitation (in mm) – Poznań-Ławica station

Years	Months												Sums
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2001	22.3	20.9	48.1	36.3	14.2	64.9	88.4	51.1	92.3	17.5	16.9	44.4	517.3
2002	29.5	64.1	45.7	37.9	70.8	40.5	24.8	67.5	21.9	96.6	43.3	9.1	551.7
2003	49.9	5.1	13.0	21.0	6.1	24.2	109.2	7.1	19.2	32.2	19.8	23.8	330.6
1951–80	29.0	28.0	26.0	37.0	53.0	62.0	71.0	59.0	48.0	11.0	37.0	37.0	498.0

Table 3. The beginning of phenological seasons in 2001–2003

Years	Phenological seasons of the year								
	Early spring	Ante spring	Spring	Early summer	Summer	Early autumn	Gold autumn	Late autumn	Winter
2001	24 I	4 V	14 V	21 V	9 VII	1 X	11 X	22 XI	25 XII
2002	4 II	28 IV	9 V	20 V	17 VI	9 IX	7 X	25 XI	7 XII
2003	13 III	24 IV	11 V	29 V	23 VI	11 IX	2 X	24 XI	4 I 04



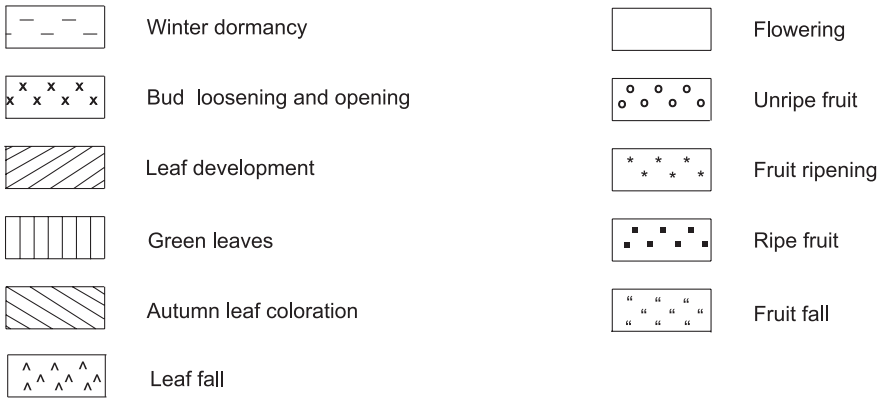


Fig. 1. The way of presentation of *S. torminalis* phenophases (explanations to Figs. 2–3)

Results

Seasonal rhythm of *S. torminalis*

Leaf development of wild service trees occurs during the period from the end of March to the beginning of May. Leaf coloration occurs in September and October, and autumn leaf fall from the beginning of October to the middle of November (Table 4; Fig. 2).

In 2002 growing season in Dendrological Garden in Poznań started in the last days of March; in 2001 – slightly later, at the beginning of April, and in 2003 it did not start until the last decade of April. An initial bud break differed between individual trees up to 6 days. The observed trees reached full foliation on the turn of April and May and there were only slightly differences in subsequent years. In Wielkopolski National Park the growing season started 1–2 weeks later than in Poznań, which is mid April in 2001 and 2002, and the turn of April and May in 2003. Full foliation *S. torminalis* trees reached in the first week of May and the differences in the phenophase timing in subsequent years and among trees were insignificant.

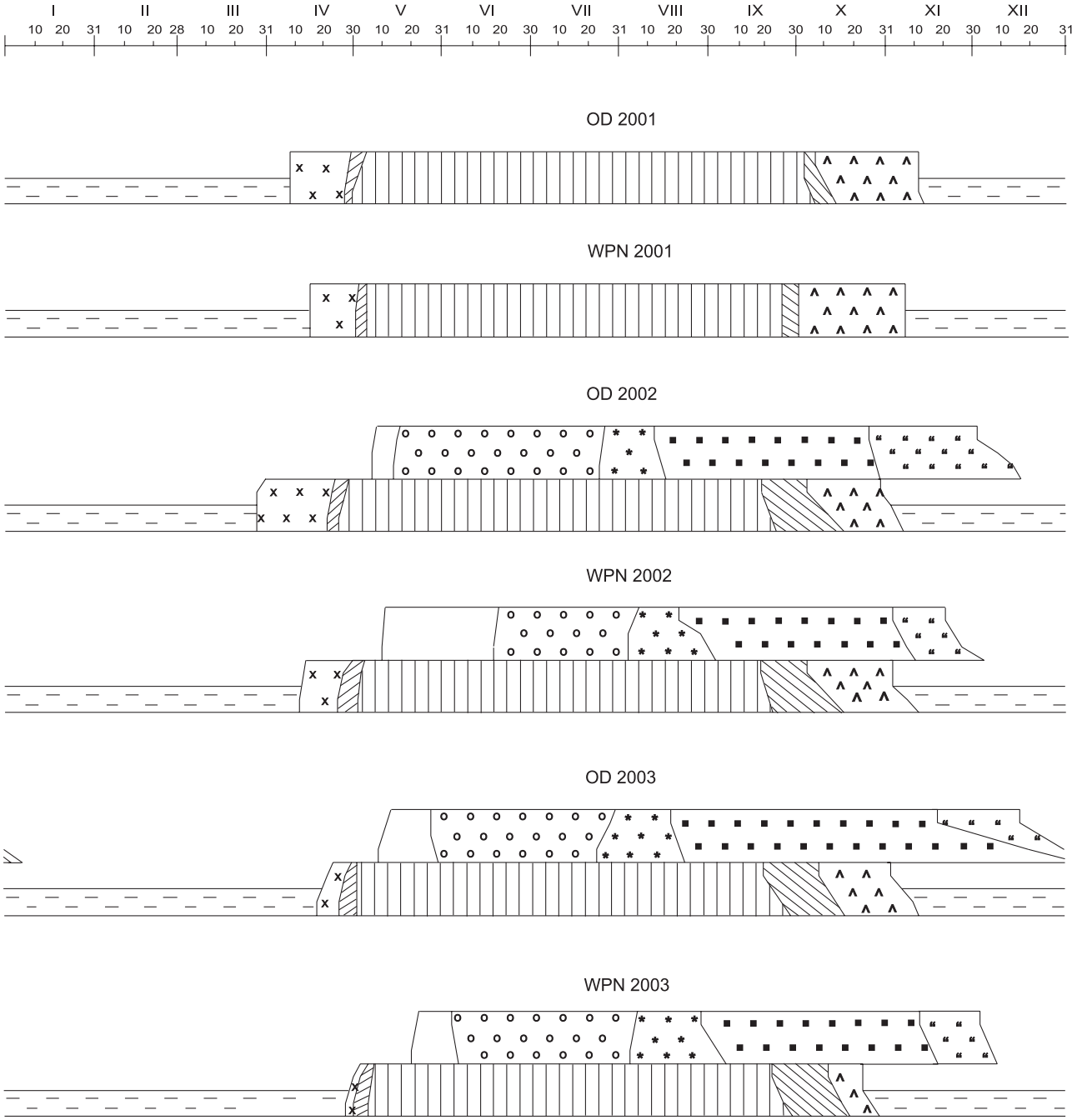


Fig. 2. The course of phenophases of *S. torminalis* trees in Dendrological Garden (OD) and Wielkopolski National Park (WPN) in 2001–2003

Table 4. Dates of phenological occurences of *S. torminalis* trees in 2001–2003

Place of observation	Number of a tree	Bud break	Foliation		Leaf coloration		Leaf fall			Flowering				Fruit ripening		Fruit fall	
			the beginning	its full	the beginning	its full	the beginning	its full	the end	the beginning	the begin. of its full	the end of its full	the end	the beginning	its full	the beginning	the end
		l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	k_1	k_2	k_3	k_4	o_1	o_2	o_3	o_4
									2001								
Dendrological Garden	1	8 IV	27 IV	30 IV	6 X	22 X	15 X	7 XI	11 XI								
	2	8 IV	29 IV	4 V	3 X	6 X	6 X	31 X	11 XI								
	3	8 IV	29 IV	4 V	3 X	26 X	12 X	7 XI	11 XI								
	4	8 IV	29 IV	4 V	6 X	31 X	12 X	9 XI	13 XI								
									2001								
Wielkopolski National Park	1	15 IV	1 V	5 V	26 IX	3 X	1 X	11 X	6 XI								
	2	15 IV	1 V	5 V	26 IX	3 X	1 X	11 X	6 XI								
	3	15 IV	2 V	5 V	26 IX	3 X	1 X	11 X	6 XI								
	4	15 IV	2 V	5 V	26 IX	3 X	1 X	11 X	6 XI								
									2002								
Dendrological Garden	1	27 III	22 IV	26 IV	18 IX	24 IX	4 X	25 X	29 X	6 V	8 V	10 V	13 V	24 VII	12 VIII	29 X	2 XII
	2	31 III	25 IV	29 IV	24 IX	7 X	16 X	29 X	6 XI	8 V	10 V	14 V	16 V	26 VII	16 VIII	25 X	9 XII
	3	27 III	24 IV	28 IV	24 IX	7 X	16 X	25 X	2 XI	7 V	9 V	13 V	15 V	26 VII	16 VIII	29 X	14 XII
	4	27 III	23 IV	28 IV	24 IX	7 X	16 X	29 X	6 XI	7 V	10 V	13 V	15 V	26 VII	16 VIII	29 X	17 XII
									2002								
Wielkopolski National Park	1	11 IV	25 IV	2 V	19 IX	3 X	8 X	27 X	3 XI	10 V	13 V	17 V	18 V	3 VIII	21 VIII	3 XI	21 XI
	2	13 IV	27 IV	3 V	23 IX	16 X	20 X	30 X	7 XI	11 V	17 V	18 V	20 V	3 VIII	27 VIII	7 XI	26 XI
	3	13 IV	27 IV	3 V	23 IX	16 X	20 X	30 X	3 XI	11 V	15 V	18 V	20 V	7 VIII	3 IX	7 XI	26 XI
	4	15 IV	30 IV	4 V	23 IX	20 X	20 X	3 XI	12 XI	11 V	15 V	18 V	20 V	7 VIII	3 IX	12 XI	5 XII
									2003								
Dendrological Garden	1	18 IV	26 IV	2 V	20 IX	3 X	9 X	21 X	2 XI	9 V	14 V	22 V	26 V	24 VII	18 VIII	19 XI	16 XII
	2	22 IV	28 IV	2 V	29 IX	12 X	17 X	3 XI	10 XI	13 V	17 V	26 V	30 V	30 VII	23 VIII	4 I 04	19 I 04
	3	24 IV	28 IV	2 V	29 IX	12 X	17 X	3 XI	10 XI	13 V	16 V	23 V	28 V	28 VII	23 VIII	20 XII	6 I 04
	4	22 IV	30 IV	2 V	29 IX	12 X	17 X	3 XI	12 XI	13 V	19 V	23 V	26 V	28 VII	23 VIII	20 XII	6 I 04
									2003								
Wielkopolski National Park	1	28 IV	30 IV	4 V	23 IX	6 X	12 X	24 X	29 X	20 V	27 V	29 V	3 VI	4 VIII	28 VIII	12 XI	3 XII
	2	30 IV	2 V	7 V	26 IX	9 X	16 X	23 X	26 X	23 V	27 V	1 VI	5 VI	6 VIII	5 IX	19 XI	9 XII
	3	30 IV	2 V	7 V	26 IX	9 X	16 X	23 X	26 X	23 V	29 V	3 VI	5 VI	6 VIII	5 IX	19 XI	9 XII
	4	2 V	4 V	7 V	29 IX	12 X	19 X	26 X	29 X	23 V	27 V	1 VI	5 VI	6 VIII	5 IX	19 XI	9 XII

Autumn leaf coloration began in Poznań in the second half of September in 2002 and 2003, and first decade of October in 2001. The phenophase reached its full during October with the exception of tree no 1 in 2002 (September 24th) and varied considerably between trees from 3 to 25 days. In Wielkopolski National Park *S. torminalis* leaves began to change their colour in the last decade of September, usually a little bit earlier than in Poznań.

In Poznań leaf fall began in October each year, it ended in the first half of November and lasted for 3–4 weeks. In 2002 leaves fell down the earliest, after strong winds. In 2001 leaf fall began before autumn coloration reached its full, in 2002 and 2003 after that. In Wielkopolski National Park *S. torminalis* leaves began to shed in first two decades of October, and ended to shed from the last decade of October till November 12th. The duration of leaf fall (l_6–l_8) varied considerably in subsequent years, from only 8–13 days in 2003 till 35 days in 2001. Quick leaf shedding in WPN in 2003 was probably the result of the sum of two factors, dry weather and strong *S. torminalis* trees competition with other species.

In 2001 *S. torminalis* trees did not bloom on both sites, but in the following two years flowering was abundant (much more in Dendrological Garden than Wielkopolski National Park). In Poznań the flowering period was rather short (5–14 days) and fell on May. In 2002 it started earlier and lasted shorter than in 2003. In Wielkopolski National Park the wild service trees started and finished flowering later.

S. torminalis fruits were ripening from the end of July till the beginning of September and usually remained on trees until December. In Poznań fruit ripening began at the end of July and reached its full after 3–4 weeks (small differences among trees). In 2002 fruit fall began at the end of October and reached its end until December 17th. In 2003 fruit fall occurred much later and the phenophase timing varied significantly among trees. The fruit remained on trees extremely long, even till January 19th 2004 in case of tree no 2. In Wielkopolski National Park fruits began to ripe and change their colour in the first decade of August. That happened about 10 days later than in Poznań. Fruit ripening reached its full on the turn of August and September. There were no significant differences in timing of these phenophases among years. Fruit fall occurred in November and the first decade of December and lasted much shorter than in Poznań.

S. torminalis phenophases at a background of phenological seasons

The course of *S. torminalis* phenophases at a background of the phenological seasons of the year were investigated only in Dendrological Garden in Poznań. The development of wild service leaves (l_1–l_3) falls on early spring and ante spring (Fig. 3). Leaf coloration and leaf fall occur in the second half of September,

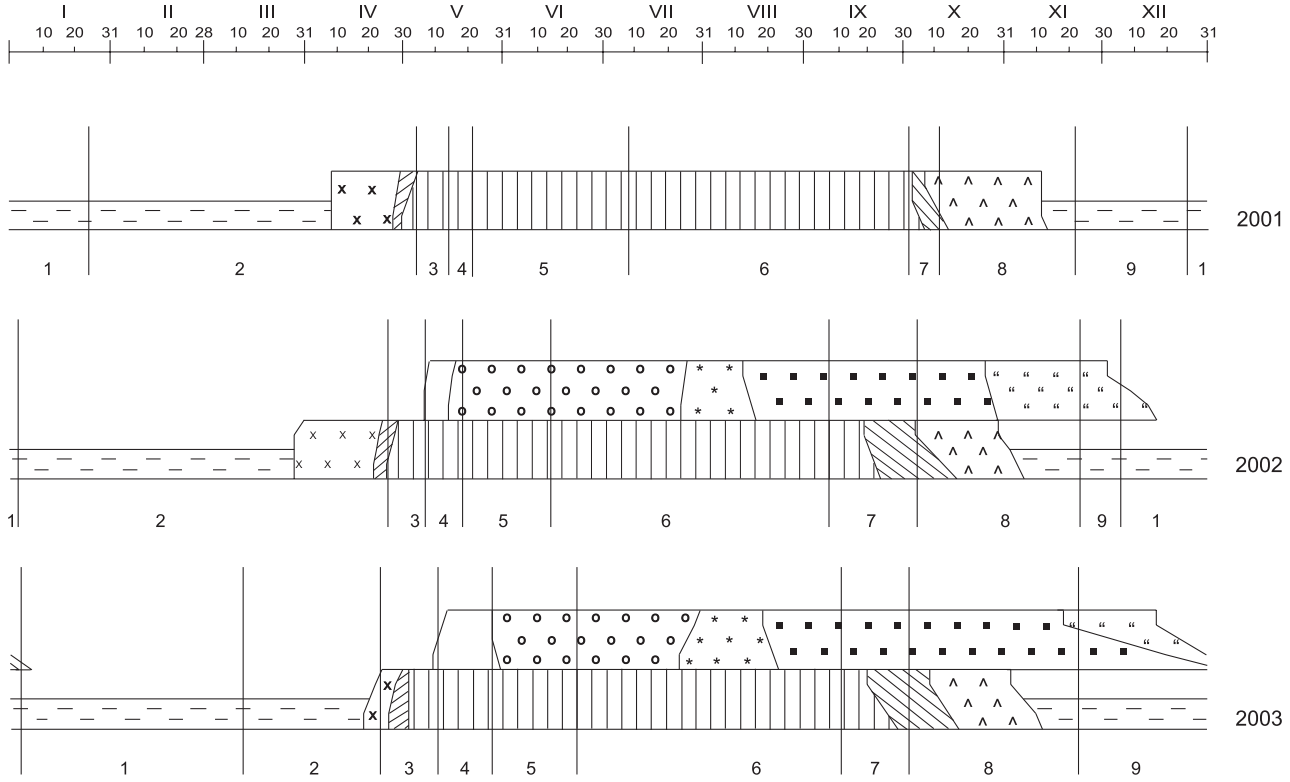


Fig. 3. *S. torminalis* phenophases at a background of the phenological seasons; 1 – winter, 2 – early spring, 3 – ante spring, 4 – spring, 5 – early summer, 6 – summer, 7 – early autumn, 8 – gold autumn, 9 – autumn

October and November and therefore last from the end of phenological summer until autumn. In 2001 the leaf fall began before reaching its full coloration. The flowering stage (k_1–k_4) did not occur in 2001. In 2002 flowering period was short and fell on spring, and in 2003 it began in ante spring and lasted till the beginning of early summer. The fruit ripening (o_1–o_2) in 2002 and 2003 lasted from the end of July to the half of August, so it fell on summer. The fruit fall occurred from the end of October to January, therefore it fell on autumn and the beginning of winter.

Discussion

The investigated wild service trees went through a full vegetative and generative development cycle in the years 2002–2003. In 2001 none of the trees were in bloom and yielded fruit. One year break in blooming and fructification is not an unusual phenomenon in woody species (Suszka et al. 1994).

The phenophases appeared in a specified order characteristic for the *Sorbus* species (Chylarecki and Straus 1968; Łukasiewicz 1978; Nowakowska 2000). Weather conditions influenced the timing (forcing or delay) of some of the phenological occurrences and phenophase duration. From our observations it appears that temperature is an important factor in regulating phenological events, especially initial bud break, leaf emergence and leaf senescence. Also the duration of flowering stage is significantly depended on temperature. Precipitation seems to have less influence on phenological occurrences. Dry weather in 2003 did not meaningly influence phenological occurrences in *S. torminalis* (except leaf fall in WPN), which may suggest that precipitation is less important climatic factor in phenological observations. Strong winds in the autumn may force leaf fall considerably. Such phenomenon was observed in 2002.

Differences in the appearance of phenological occurrences were observed among *S. torminalis* trees which grew on two different sites. The comparison of daily mean temperature between Jeziory (WPN) and Poznań-Ławica stations made for a 20-month period (2001–2002) showed very small differences, statistically significant only for 5 months of the studied period (Bednorz 2003). Hence the differences in phenological events seemed to have resulted from environmental and microclimatic conditions. The vegetative and generative development cycle started earlier and lasted longer in Dendrological Garden in Poznań where trees had better light and edaphic conditions. *S. torminalis* is also very sensitive to competition (Drapier 1993; Demesure 2001) which is much higher in the woods of WPN than Dendrological Garden. There were also differences observed among trees growing on the same site which was probably due to individual characteristics of specimens and different light conditions.

Phenophases of *S. torminalis* are in general synchronised with the phenological seasons of the year. The results of 3-year observations of four other *Sorbus* species carried out in Szczecin (Nowakowska 2000) showed that only some phenophases and only of some species are distinctly synchronised with the phenological seasons.

This study presents preliminary results of ongoing investigation on the timing of *S. torminalis* development events started in 2001 and also points out the need for long-term data sets.

Acknowledgements

We would like to thank M. Grześkowiak for help with field observations in 2001 and A. Mularski for linguistic verification of the manuscript.

References

Bednorz E. 2003. Wstępne porównanie średniej dobowej temperatury powietrza dwóch stacji meteorologicznych w rejonie Poznania. Badania Fizjograficzne nad Polską Zachodnią Seria A 54: 21–25.

Boratyński A., Barzdajn W. 1998. Ochrona lokalnych populacji rzadkich i ginących gatunków drzew. In: Botanika polska u progu XXI wieku. Materiały sympozjum i obrad sekcji 51 Zjazdu Polskiego Towarzystwa Botanicznego, Gdańsk, 15–19 września 1998. Mądlikowska J. (ed.). Bogucki Wyd. Nauk., Poznań, pp. 53.

Browicz K., Gostyńska-Jakuszewska M. 1966. Atlas rozmieszczenia drzew i krzewów w Polsce. 5. PWN, Warszawa–Poznań.

Chylarecki H., Straus H. 1968. Wyniki dziesięcioletnich obserwacji fenologicznych nad drzewami i krzewami w Arboretum Kórnickim. Arboretum Kórnickie 13: 37–120.

Demesure B. 2001. The wild service tree. In: Forest Genetic Resources Management and Conservation. France as a Case Study. Teissier du Cros E. (ed.). Ministry of Agriculture and Fisheries, Bureau of Genetic Resources Commission of Forest Genetic Resources, INRA DIC, Paris, pp. 52–53.

Drapier N. 1993. Écologie de l'alisier torminal, *Sorbus torminalis* (L.) Crantz. Revue Forestière Française 45 (3): 229–243.

Łukasiewicz A. 1978. Rozwój drzew i krzewów na terenie miasta Poznania. Prace PTPN, Wydział Matematyczno-Przyrodniczy, Komisja Biologiczna 49, PWN, Warszawa–Poznań.

Łukasiewicz A. 1984. Potrzeba ujednolicenia metodyki fenologicznej w polskich ogrodach botanicz-

nych i arboretach. Wiadomości Botaniczne 28 (2): 153–158.

Nowakowska M. 2000. Fenologia wybranych gatunków jarzębu *Sorbus* na terenie Szczecina. Folia Universitatis Agriculturae Stetinensis 215 Agricultura (86): 17–73.

Olaczek R. 1976. Zmiany w szacie roślinnej Polski od połowy XIX wieku do lat bieżących. Zeszyty Problemowe Postępów Nauk Rolniczych 177: 369–403.

Pacyniak C. 1991. Wprowadzajmy do lasów jarząb brekinię. Las Polski 6: 10–11.

Rozporządzenie Ministra Środowiska z dnia 9 lipca 2004 r. w sprawie gatunków dziko występujących roślin objętych ochroną (Dz. U. Nr 168, poz. 1764).

Stecki K. 1950. Brekinia, ginące drzewo naszych lasów. Chrońmy Przyrodę Ojczystą 6,1–2: 3–11.

Suszka B., Muller C., Bonnet-Masimbert M. 1994. Nasiona leśnych drzew liściastych. Od zbioru do siewu. Wydawnictwo Naukowe PWN, Warszawa–Poznań.

Żukowski W., Jackowiak B. 1995. Lista roślin naczyniowych ginących i zagrożonych na Pomorzu Zachodnim i w Wielkopolsce. In: Żukowski W., Jackowiak B. (eds.). Ginące i zagrożone rośliny naczyniowe Pomorza Zachodniego i Wielkopolski. Prace Zakładu Taksonomii Roślin UAM, 3: 9–96. Poznań.