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A COMPARATIVE ANALYSIS OF DYNAMICS OF STEM GROWTH AND PHENOLOGICAL STAGES OF *RUBUS* SPECIES IN CULTIVATION

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ABSTRACT. In recent years extensive attention has been given to the *Rubus* genus, but knowledge on the ecology of most of its species, including rhythmic development, is still insufficient. Such data may have practical applications, since blackberry species are economically important. The goal of the study was to analyse phenology and growth rate of vegetative and generative stems in 10 *Rubus* species of different systematic affinity (belonging to two subspecies and three sections), growing in the Dendrological Garden of the Poznań University of Life Sciences. Some habitat factors were also taken into consideration. Field investigations were carried out for three growing seasons. The plants were evaluated for phenology twice a week, while the length of their stems was measured once a week. Differences were observed in the seasonal rhythm of individual species. Weather factors distinctly influenced the course of development phases in all the *Rubus* species. Drought during the growing season caused flowering disorders, withering of fruit, earlier autumn leaf coloration, and fall of leaves. *Rubus idaeus* and *R. fabrimontanus* ripened all of their fruits each year of observations and seemed to be the most adapted for fruit production. *Rubus fabrimontanus*, *R. kuleszae* and *R. praecox* were the most vigorous species with reference to shoot growth. This study revealed that only some species were fully acclimated to the conditions of the Dendrological Garden, since they successfully completed their entire flowering and fruiting cycles.

KEY WORDS: *Rubus*, phenology, growth rate, Dendrological Garden, Poznań

INTRODUCTION

Eighty-eight species of *Rubus* L. have been noted in Poland so far. With the exception of a few diploid species, they are polyploids and apomicts of hybrid origin within the subgenus *Rubus* (Zieliński 2004). Most of these species are common plants, but their distribution within Poland is irregular, with the greatest diversity found in southwestern Poland with over 70 species and the least in the north with only five species (Zieliński 2001). *Rubus* species are very important to natural ecosystems, especially in early forest successions. They are one of the basic components of thermophilic shrubby thickets of the *Prunetalia* order (Matuszkiewicz 2006). Moreover, many *Rubus* species are often very invasive and can indicate synanthropization of plant vegetation. *Rubus* representatives are also economically important as fruit crops, ornamentals and medicinal plants. Leaves and fruits of all blackberry species contain polyphenolic compounds and some vitamins, having a broad spectrum of biological activity. These compounds are beneficial to human health and their presence in vegetable extracts and diet may prevent lifestyle diseases (Gudej and Tomczyk 2004, Venskutonis et al. 2007, Milivojević et al. 2007).

The *Rubus* genus exhibits an enormous morphological diversity and is one of the genera of flowering plants most difficult to classify taxonomically (Lawrence and Campbell 1999). However, owing to the concept of agamic species proposed by Weber (1996) we may observe an extension of the scope of investigations to include this group of plants. They mainly refer to chorology of different *Rubus* species, or to their systematics and genetics and much less frequently to their ecology and biology, including phenological observations (e.g. Kraft et al. 1996, Weber 1996, 1999, 2000, 2007, Matzke-Hajek 1999, Kollmann et al. 2000, Zieliński 2001, 2004, Abbate et al. 2002, Zieliński et al. 2004, Trávniček and Zázvorka 2005, Žila and Weber 2005, Bijlsma and Haveman 2007, Lepši and Lepši 2009, Tomlik-Wyremblewska et al. 2010).

Since 2008 we have been conducting studies on the phenology, dynamics of stem growth rate, morphological variability of leaves, and phytochemical analyses of leaf extracts of native *Rubus* species growing in the National Collection of Blackberries in the Dendrological Garden of the Poznań University of Life Sciences (Kluza-Wieloch and Maciejewska-Rutkowska 2009).

The goal of our current study was to compare rhythmic development – phenology and growth rate of

vegetative and generative stems in 10 *Rubus* species of different systematic affinity, taking into consideration some habitat factors (temperature and precipitation).

MATERIALS AND METHODS

Investigations were conducted on 10 *Rubus* species, representing subgenus *Idaeobatus* – *R. idaeus* L. and subgenus *Rubus* – *R. allegheniensis* Porter, *R. canadensis* L., *R. gracilis* J. Presl & C. Presl., *R. praecox* Bertol. (section *Rubus*); *R. fabrimontanus* (Sprib.) Sprib., *R. gothicus* Frid. & Gelert ex E.H.L. Krause, *R. hevellicus* (E.H.L. Krause) E.H.L. Krause, *R. kuleszae* Ziel. (section *Corylifolii*) and *R. caesius* L. (section *Caesii*). *Rubus* species growing in the Dendrological Garden of the Poznań University of Life Sciences were observed. The species terminology following Zieliński (2004) was applied. The analysed brambles grew in the south-western part of the Dendrological Garden of the Poznań University of Life Sciences, covering an area of about 0.5 ha. The site conditions were similar. Each observed species was represented by a single specimen, forming a rank cluster.

Field investigations were carried out starting from January 2008. *Rubus* species were evaluated for phenology twice a week. The dates of individual phenological stages were determined according to Łukasiewicz (1984). Analyses of vegetative organs concerned the development of leaf buds and changes of leaf tint, while generative organs were investigated in terms of the development of flowers and fruits. The phenological stages were as follows: 1 – leaf buds just opening, 2 – leaf buds half-opened (the first leaves unfolded, showing their top leaflets), 3 – beginning of autumn coloration of leaves (about 10% of leaves coloured), 4 – beginning of full autumn coloration (about 50% of leaves coloured), 5 – the end of full autumn coloration (about 90% of leaves coloured), 6 – loss of decorative leaf coloration, 7 – beginning of leaf fall, 8 – the end of leaf fall, 9 – first flower buds visible, 10 – first flowering (a few fully opened flowers), 11 – beginning of full flowering (approximately 25% opened flowers), 12 – first flowers petal drop (first flower petals withered or fell), 13 – the end of full flowering (about 75% of flowers past petal fall), 14 – the last flowers buds, 15 – the end of flowering (the date when last flowers dropped their petals), 16 – beginning of fruit ripening (first fruits with visible changes of colour), 17 – full ripeness (more than 50% fruits of proper colour); 18 – the end of ripening (all fruits were ripe), 19 – beginning of pyrene dispersion, 20 – full pyrene dispersion (50% pyrenes spread), 21 – the end of pyrene dispersion (at most individual fruits on the plant).

The dynamics of growth rate was investigated on selected, single vegetative and generative stems of all observed *Rubus* species. For this purpose their length was measured each week from the start of the growing season. The same stems were analysed at all times. In addition, after growth stopped 25 shoots of both types were measured.

The weather conditions were also analysed based on the meteorological data for the city of Poznań (TuTiempo.net 2011). The distribution of the following parameters: mean temperature (°C), minimum temperature (°C), maximum temperature (°C) and total precipitation (mm) was investigated throughout the period of field observations (Table 1).

Table 1. Weather conditions of the investigated object, basing on the meteorological data of Poznań (TuTiempo.net 2011)

Month ↓	Mean temperature (°C)			Minimal temperature (°C)			Maximal temperature (°C)			Precipitation amount (mm)		
Year →	2008	2009	2010	2008	2009	2010	2008	2009	2010	2008	2009	2010
January	2.2	–3.2	–6.8	–9.0	–19.0	–21.0	11.0	4.0	–1.0	70.08	19.03	29.20
February	4.1	–0.5	–1.0	–7.0	–2.0	–13.0	15.0	3.0	10.0	13.96	32.25	17.03
March	4.4	3.7	3.5	–6.0	–4.0	–13.0	18.0	12.0	22.0	54.87	51.31	27.68
April	8.5	11.3	8.9	–1.0	–1.0	–1.0	21.0	26.0	26.0	83.56	20.54	43.43
May	13.8	13.1	11.6	2.0	2.0	3.0	27.0	29.0	22.0	10.92	81.81	110.75
June	17.6	15.7	17.0	6.0	3.0	6.0	30.0	29.0	32.0	10.42	110.49	17.02
July	19.7	19.5	21.7	10.0	11.0	10.0	31.0	29.0	36.0	54.09	93.72	80.53
August	18.5	19.1	18.8	7.0	8.0	10.0	32.0	31.0	30.0	76.20	23.62	154.43
September	13.4	15.6	12.6	3.0	2.0	4.0	28.0	28.0	23.0	19.04	30.99	74.16
October	9.4	7.1	6.6	–2.0	–4.0	–4.0	21.0	23.0	16.0	59.68	51.81	7.37
November	5.1	6.7	4.7	–4.0	–3.0	–13.0	16.0	13.0	17.0	21.83	37.59	100.56
December	0.9	–1.1	–5.9	–8.0	–17.0	–18.0	9.0	8.0	4.0	26.43	31.74	61.20
Mean/*Sum	9.8	8.9	7.6	–0.8	–2.0	–4.2	21.6	19.6	19.8	*501.08	*584.90	*723.36

RESULTS

No cold injury was observed in spite of periods of relatively low temperature during the winter months in the years 2009-2010. In 2008, the first year that we monitored growth, a mild winter forced bud development about one week earlier in all the species but one, when compared to our observations in the other two years. The exception was *R. allegheniensis* that was the latest to break bud each year. *Rubus idaeus* and *R. kuleszae* started their growth a little earlier than the other species. Leaf buds always developed faster in *R. caesius*. The leaves unfolded after 3-7 days for all species except for *R. gracilis*, which took more than 25 days. Besides, young leaves of *R. praecox* and *R. hevellicus* developed over 15 days in the last year of investigations (Tables 1-2).

The beginning and full autumn leaf coloration was earliest in 2009 and latest in 2010 for all species except for *R. caesius*. Changes of leaf colour were closely connected with the amount of rainfall in the summer, especially at the end of August and the beginning of September. On the other hand, the end of full coloration of leaves was only observed in *R. idaeus* (twice) and *R. caesius* (once). The other investigated species appeared to have almost half of leaves without colour change and they had just frozen and fallen off with the beginning of cold temperatures in the autumn. *Rubus fabrimontanus* and *R. kuleszae* were the first to lose their autumn color in 2009 and the last in 2008 (the first ten days of December; however, in the same time foliage of three species did not change). Then, the beginning of leaf fall was recorded at the earliest time point in 2009 and latest in 2010. The end of autumn leaf fall was observed only in *R. idaeus*, as all the other taxa kept at least 5% and up to 70% of their foliage (Table 2).

The earliest flower buds started to develop at the beginning of the last decade of April. Generative buds were not noticeable until the first week of May in 2008 due to a spring drought. In 2010 they appeared even later on *R. praecox* and *R. gracilis*. Usually the first flowers were observed on these species in the first half of May, but they were not found until the beginning of July in 2010. In the first year of observation full flowering took 4-7 days and in the next year up to 15 days. Flowering

Table 2. Date specification of the phenological stages for the investigated species in the years 2008-2010. Phenological stages (1-21) as in "Materials and methods"

Phenological stage	Year	*Rubus* species									
		idaeus	*allegheniensis*	*canadensis*	*gracilis*	*praecox*	*fabrimontanus*	*gothicus*	*hevellicus*	*kuleszae*	*caesius*
1	2	3	4	5	6	7	8	9	10	11	12
1	2008	18.03	04.04	21.03	28.03	28.03	25.03	21.03	28.03	18.03	18.03
	2009	26.03	03.04	29.03	03.04	29.03	29.03	29.03	29.03	26.03	23.03
	2010	23.03	29.03	25.03	29.03	29.03	28.03	25.03	28.03	28.03	23.03
2	2008	21.03	15.04	28.03	18.04	04.04	28.03	28.03	04.04	21.03	21.03
	2009	03.04	16.04	06.04	30.04	06.04	06.04	06.04	06.04	03.04	03.04
	2010	29.03	15.04	01.04	15.04	20.04	01.04	01.04	13.04	01.04	29.03
3	2008	18.09	22.09	25.09	25.09	22.09	25.09	29.09	25.09	29.09	13.10
	2009	20.08	27.08	31.08	20.08	20.08	20.08	27.08	31.08	03.09	27.08
	2010	28.09	12.10	05.10	15.10	15.10	12.10	05.10	08.10	08.10	15.10
4	2008	13.10	19.10	09.10	13.10	09.10	16.10	13.10	06.10	09.10	14.11
	2009	28.09	09.10	05.10	10.09	17.09	21.09	24.09	24.09	21.09	28.09
	2010	08.10	28.09	19.10	22.10	22.10	22.10	22.10	15.10	19.10	22.10
5	2008	24.11	–	–	–	–	–	–	–	–	01.12
	2009	–	–	–	–	–	–	–	–	–	–
	2010	26.10	–	–	–	–	–	–	–	–	–
6	2008	–	03.11	–	05.12	05.12	01.12	–	05.12	28.11	12.12
	2009	26.10	05.10	26.10	26.10	29.10	28.09	12.10	08.10	28.09	08.10
	2010	22.10	12.10	22.10	26.10	26.10	26.10	26.10	22.10	22.10	26.10

Table 2 – cont.

1	2	3	4	5	6	7	8	9	10	11	12
7	2008	25.09	06.10	29.09	09.10	29.09	29.09	09.10	29.09	09.10	20.10
	2009	17.09	21.09	21.09	17.09	03.09	07.09	14.09	21.09	21.09	17.09
	2010	05.10	19.10	12.10	19.10	19.10	15.10	12.10	15.10	15.10	19.10
8	2008	08.12	10%	05%	50%	70%	50%	30%	35%	15%	02%
	2009	12.12	05%	05%	15%	10%	50%	10%	50%	05%	05%
	2010	09.11	15%	10%	45%	45%	40%	20%	45%	20%	10%
9	2008	05.05/ 30.08	02.05	02.05	09.05	05.05/ 01.08	02.05	05.05	09.05	05.05/ 11.08	02.05/ 15.09
	2009	27.04	30.04	20.04	01.06	30.04	30.04/ 07.09	30.04	27.04	27.04	22.04/ 02.07
	2010	20.04	04.05	30.04.	28.05	28.05/ 14.09	27.04	04.05	30.04/ 11.08	04.05	27.04
10	2008	25.05/ 07.09	19.05	16.05	06.06	16.06/ 08.08	26.05	02.06	02.06	30.05/ 14.08	19.05/ 22.09
	2009	14.05	04.06	18.05	06.07	08.06	25.05/ 10.09	28.05	08.06	01.06	18.05/ 06.07
	2010	31.05	14.06	04.06	02.07	02.07/ 24.09	04.06	14.06	21.06/ 25.08	18.06	31.05
11	2008	30.05	26.05	23.05	16.06	23.06/ 14.08	06.06	09.06	09.06	09.06/ 21.08	26.05/ 25.09
	2009	18.05	18.06	01.06	13.07	25.06	01.06/ 14.09	04.06	18.06	15.07	25.05/ 18.07
	2010	04.06	21.06	07.06	09.07	09.07/ 12/ 10	21.06	25.06	28.06/ 14.09	25.06	07.06
12	2008	26.05/ 10.09	23.05	19.05	09.06	20.06/ 11.08	30.05	06.06	06.06	06.06/ 18.08	30.05/ 02.10
	2009	21.05	11.06	25.05	09.07	11.06	28.05/ 17.09	01.06	11.06	08.06	21.05/ 13.07
	2010	11.06	18.06	11.06	05.07	05.07/ 08.10	14.06	18.06	25.06/ 07.09	21.06	04.06
13	2008	06.06	09.06	09.06	23.06	30.06/ 21.08	09.06	27.06	20.06	20.06/ 28.08	09.06/ 09.10
	2009	25.05	25.06	08.06	18.07	13.07	22.06/ 24.09	22.06	29.06	09.06	28.05
	2010	14.06	25.06	21.06	16.07	12.07/ 19.10	05.07	02.07	20.07/ 21.09	02.07	18.06
14	2008	02.06	27.06	27.06	30.06	18.07/ 18.08	23.06	09.10	02.10	25.07/ 18.09	23.06/ 20.10
	2009	01.06	29.06	11.06	20.07	31.08	02.07/ 05.10	03.09	06.08	13.08	13.08
	2010	25.06	09.07	28.06	12.07	26.07/ 02.11	09.07	09.07	09.07/ 02.11	09.07	05.07
15	2008	09.06	11.07	11.07	04.07	25.07/ 25.08	11.07	20.10	09.10	01.08/ 02.10	30.06/ 30.10
	2009	04.06	06.07	25.06	23.07	10.09	09.07/ 08.10	10.09	13.08	20.08	20.08
	2010	28.06	12.07	12.07	19.07	03.08/ 09.11	12.07	12.07	12.07/ 09.11	12.07	12.07

Table 2 – cont.

1	2	3	4	5	6	7	8	9	10	11	12
16	2008	23.06	–	28.07	04.08	18.08	07.07	18.07	14.07	30.06	–
	2009	15.06	30.07	30.07	–	17.08	13.07	2707	18.07	20.07	–
	2010	02.07	10.08	26.07	10.08	10.08	19.07	19.07	19.07	19.07	03.08
17	2008	27.06	–	–	–	–	25.07	–	01.08	–	–
	2009	02.07	31.08	20.08	–	10.09	24.08	24.08	27.07	03.08	–
	2010	09.07	–	10.08	–	23.08	10.08	10.08	17.08	03.08	–
18	2008	04.07	–	–	–	–	28.08	–	–	–	–
	2009	13.07	–	–	–	–	–	–	03.09	–	–
	2010	12.07	–	–	–	21.09	–	–	–	–	–
19	2008	25.07	–	–	–	–	18.08	01.09	08.08	04.08	–
	2009	09.07	24.08	13.07	–	24.08	17.08	17.08	03.08	10.08	–
	2010	19.07	–	23.08	–	23.08	13.08	13.08	23.08	10.08	–
20	2008	01.08	–	–	–	–	01.09	–	–	–	–
	2009	23.07	–	17.09	–	–	–	17.09	14.09	–14.09	–
	2010	03.08	–	–	–	–	–	–	–	–	–
21	2008	08.08	–	90% – w	90% – w	90% – w	15.09	80% – w	75% – w	70% – w	–
	2009	03.08	60%	50%	–	40%	45%	40%	35%	50%	–
	2010	20% – w	90% – w	40%	95% – w	40%	80% – w	70% – w	45% – w	40% – w	95% – w

Explanation: w – withered, % – remains of fruits or leaves, two dates separated by a slash (/) means repeated flowering.

on the first flowers usually was complete after 3-5 days. The end of full flowering occurred in June, but varied in individual years of observations. The shortest flowering time was recorded in *R. idaeus* and that was why the last flower buds were always visible on stems of this species. The longest flowering was observed in *R. gothicus* and *R. hevellicus* in 2008. These species continuously formed flowers from the beginning of June up to mid-October. A second flowering was relatively rare and was only observed in four species in 2008 and two species in 2009 and 2010. It did not appear in any species every year. However, *R. caesius* and *R. praecox* reflowered two years running and in 2010 they had open flowers up to the first ten days of November (Table 2).

Every year of investigation had the earliest beginning and end of fruit ripening were recorded for *R. idaeus*. The entire cycle of fruiting from flowering to all of the fruit falling from the plant was only observed in this species and in *R. fabrimontanus*. The other *Rubus* species did not drop all of their fruit. Late flowering or a shortage of water caused fruits drying out and some of them (20-95%) remained on the shrubs even throughout winter. Generally, the first fruit started to spread 2-4 weeks after they had ripened. In some years of observations *R. gracilis, R. allegheniensis* and *R. caesius* did not form fruits at all (Table 2).

The generative stems of *R. canadensis*, *R. fabrimontanus* and *R. caesius* were the first to start growth in the last week of March in 2008. At the same time they developed biennial stems in the shortest period. The generative stems of *R. gracilis* were the last to start their growth in 2009, not until after the first week of May. However, *R. gracilis* was noted to have the longest time of shoot growth up to the turn of June and July. On average, the longest biennial stems were found in *R. praecox* and the shortest in *R. canadensis*. Most of the species had their greatest growth in 2010 (Tables 2-3).

The first vegetative stems emerged after the third week of April for seven species in 2009 and for three in 2010. In all species the primocanes finished their vegetative growth earliest in 2008 because of a shortage of precipitation. They grew for the longest period of time in 2010, when some blackberry species finished their growth naturally, by tip rooting at the end of September. During the entire period of observations vegetative shoots of *R. canadensis* appeared to finish their growth the fastest. On average, the longest annual stems were noted at all investigated species in 2010. Then the longest one (539 cm) was observed in *R. fabrimontanus* in 2009 and the shortest in *R. allegheniensis* and *R. idaeus* in all the years of investigations (Tables 2-4).

Table 3. Growth rate of generative shoots of 10 analysed *Rubus* species (cm) in years 2008-2010

Rubus species	Year ↓	Growth rate (cm)																Average growth/ year (30 n)
	month →	March		April				May				June				July		
	week →	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	
R. idaeus	2008	–	–	0.5	1.0	2.5	3.0	5.0	7.0	14.0	15.0	–	–	–	–	–	–	12.3
	2009	–	–	0.5	1.0	1.5	2.0	9.0	10.5	12.0	–	–	–	–	–	–	–	17.8
	2010	–	–	3.0	4.5	6.0	10.0	14.0	15.0	25.0	33.0	38.0	45.0	46.0	–	–	–	38.5
R. alleghe-niensis	2008	–	–	–	–	0.5	1.5	4.0	10.0	16.5	18.0	–	–	–	–	–	–	13.3
	2009	–	–	–	–	0.5	2.5	10.0	15.0	22.0	–	–	–	–	–	–	–	27.5
	2010	–	–	–	1.0	2.0	4.0	8.0	10.0	15.0	22.0	27.0	35.0	40.0	46.0	50.0	–	34.3
R. cana-densis	2008	–	0.5	1.0	1.5	3.0	4.5	9.0	15.0	15.5	17.0	18.0	–	–	–	–	–	14.5
	2009	–	–	1.5	2.0	4.0	6.0	8.5	11.0	12.0	13.0	14.0	–	–	–	–	–	12.5
	2010	–	–	1.5	2.0	2.5	4.5	6.5	9.0	11.0	13.0	14.0	15.0	16.0	–	–	–	17.0
R. gracilis	2008	–	–	–	0.5	1.5	0.3	7.5	25.0	27.0	30.0	32.0	35.0	38.0	41.0	–	–	48.7
	2009	–	–	–	–	–	–	1.0	5.0	16.0	22.0	27.0	30.0	32.0	34.0	35.0	–	33.5
	2010	–	–	–	1.0	2.0	6.0	12.0	21.0	27.0	38.0	39.0	40.0	41.0	42.0	43.0	–	40.8
R. prae-cox	2008	–	–	1.0	1.5	2.0	3.5	6.0	13.0	23.0	24.0	–	–	–	–	–	–	75.3
	2009	–	–	0.5	1.0	1.5	2.0	2.5	13.0	16.0	18.0	19.0	21.0	22.0	23.0	24	–	65.0
	2010	–	–	–	1.0	1.5	2.5	3.5	5.0	10.0	18.0	23.0	32.0	40.0	45.0	46.0	–	60.2
R. fabri-montanus	2008	–	0.5	1.0	1.5	2.5	3.5	5.5	6.5	7.0	8.0	–	–	–	–	–	–	39.2
	2009	–	–	–	1.0	6.0	8.5	17.0	36.0	48.0	58.0	60.0	63.0	66.0	68.0	–	–	49.3
	2010	–	–	1.5	2.5	3.5	7.0	13.0	21.0	22.0	23.0	24.0	–	–	–	–	–	58.7
R. gothi-cus	2008	–	–	0.5	1.0	1.5	2.5	4.5	12.0	17.0	24.5	–	–	–	–	–	–	31.9
	2009	–	–	–	0.5	1.0	1.5	6.0	16.0	24.0	27.0	31.0	33.0	34.0	–	–	–	37.0
	2010			1.5	2.0	3.0	6.0	10.0	16.0	21.0	28.0	33.0	40.0	41.0	42.0	–	–	44.0
R. hevelli-cus	2008	–	–	0.5	1.0	2.5	3.0	5.0	11.5	14.0	15.0	–	–	–	–	–	–	43.3
	2009	–	–	–	0.5	1.0	1.5	9.0	23.0	29.0	33.0	36.0	40.0	42.0	43.0	–	–	45.0
	2010	–	–	–	1.0	1.5	3.0	4.5	6.0	8.0	11.0	29.0	41.0	46.0	51.0	52.0	–	51.3
R. kule-szae	2008	–	–	0.5	1.0	3.0	4.5	7.5	11.0	13.0	13.5	14.0	–	–	–	–	–	62.5
	2009	–	–	–	1.0	2.0	3.5	11.5	28.0	44.0	54.0	57.0	60.0	64.0	65.0	–	–	53.8
	2010	–	–	1.5	2.5	3.5	7.0	14.0	24.0	32.0	43.0	50.0	59.0	60.0	61.0	–	–	61.2
R. caesius	2008	–	0.5	1.0	1.5	3.0	5.5	10.0	13.0	16.0	18.0	19.0	–	–	–	–	–	31.0
	2009	–	–	0.5	2.5	4.5	11.5	18.0	19.0	21.0	34.0	35.0	36.0	–	–	–	–	23.2
	2010	–	–	1.5	2.0	3.0	5.0	7.0	10.0	12.0	16.0	18.0	20.0	21.0	–	–	–	24.3

TABLE 4. Growth rate of vegetative shoots (cm) of 10 analysed *Rubus* species in years 2008-2010

Rubus species	Year ↓	Growth rate (cm)																						Average growth/ year (30 n)
	month →	April		May				June				July				August				September				
	week →	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
R. idaeus	2008	–	5.0	12.0	25.0	28.0	29.0	30.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	52.2
	2009	12.0	13.0	37.0	41.0	50.0	57.0	64.0	67.0	79.0	84.0	95.0	108.0	120.0	125.0	–	–	–	–	–	–	–	–	78.2
	2010	3.5	7.0	11.0	15.0	17.0	22.0	48.0	75.0	86.0	90.0	92.0	95.0	96.0	97.0	100.0	103.0	107.0	110.0	112.0	113.0	115.0	117.0	127.2
R. alleghe-niensis	2008	–	–	5.0	15.0	38.0	42.5	43.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	44.5
	2009	–	–	7.0	11.0	15.0	29.0	41.0	63.0	66.0	68.0	70.0	73.0	77.0	83.0	90.0	102.0	113.0	118.0	–	–	–	–	79.3
	2010	–	2.0	3.0	5.0	6.0	8.0	27.0	69.0	82.0	97.0	98.0	100.0	102.0	104.0	114.0	122.0	129.0	132.0	138.0	143.0	147.0	151.0	136.5
R. cana-densis	2008	–	4.0	11.0	33.0	51.0	64.0	65.0	66.0	67.0	–	–	–	–	–	–	–	–	–	–	–	–	–	92.7
	2009	–	2.0	8.0	13.0	15.0	19.0	22.0	24.0	26.0	29.0	31.0	37.0	48.0	–	–	–	–	–	–	–	–	–	89.7
	2010	–	2.0	5.0	8.0	16.0	27.0	38.0	55.0	69.0	85.0	86.0	87.0	88.0	89.0	–	–	–	–	–	–	–	–	189.2
R. gracilis	2008	–	–	5.0	11.0	29.0	39.0	53.0	59.0	68.0	–	–	–	–	–	–	–	–	–	–	–	–	–	128.7
	2009	–	8.0	27.0	39.0	65.0	79.0	91.0	101.0	117.0	131.0	144.0	179.0	193.0	202.0	–	–	–	–	–	–	–	–	132.5
	2010	–	–	–	–	7.0	31.0	35.0	42.0	67.0	95.0	96.0	98.0	99.0	101.0	124.0	139.0	152.0	175.0	189.0	196.0	203.0	215.0	215.8
R. prae-cox	2008	–	5.0	13.0	27.0	38.0	41.5	47.0	51.0	54.0	57.0	–	–	–	–	–	–	–	–	–	–	–	–	210.5
	2009	13.0	25.0	50.5	58.0	70.0	81.0	94.0	109.0	111.0	113.0	115.0	122.0	130.0	–	–	–	–	–	–	–	–	–	217.4
	2010	–	5.0	17.0	30.0	44.0	62.0	79.0	100.0	121.0	148.0	159.0	172.0	179.0	185.0	219.0	274.0	309.0	351.0	370.0	391.0	402.0	416.0	461.0

TABLE 4 – cont.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
R. fabrimontanus	2008	–	11.0	26.0	64.0	99.0	129.0	162.0	189.0	202.0	230.0	250.0	271.0	284.0	298.0	315.0	328.0	340.0	362.0	–	–	–	–	169.5
	2009	12.0	28.0	64.0	88.0	117.0	134.0	159.0	181.0	209.0	274.0	349.0	411.0	470.0	495.0	521.0	534.0	539.0	–	–	–	–	–	342.8
	2010	–	4.0	17.0	34.0	49.0	63.0	81.0	101.0	162.0	200.0	220.0	240.0	281.0	333.0	394.0	427.0	459.0	492.0	497.0	501.0	508.0	517.0	444.5
R. gothicus	2008	–	–	3.5	21.0	49.0	68.0	82.0	85.0	88.0	–	–	–	–	–	–	–	–	–	–	–	–	–	89.2
	2009	5.5	12.0	15.0	17.0	19.0	20.0	22.0	23.0	27.0	31.0	34.0	37.0	38.0	–	–	–	–	–	–	–	–	–	69.4
	2010	–	4.0	9.0	14.0	17.0	23.0	30.0	38.0	47.0	78.0	90.0	115.0	120.0	124.0	151.0	174.0	190.0	208.0	217.0	229.0	242.0	254.0	312.3
R. hevellicus	2008	–	–	8.0	22.0	44.0	65.0	82.0	85.0	89.0	–0	–	–	–	–	–	–	–	–	–	–	–	–	206.2
	2009	1.0	9.5	32.0	50.0	73.0	97.0	121.0	148.0	157.0	179.0	194.0	207.0	225.0	239.0	254.0	–	–	–	–	–	–	–	215.4
	2010	–	5.0	11.0	19.0	31.0	45.0	52.0	62.0	73.0	90.0	94.0	100.0	102.0	103.0	121.0	149.0	160.0	176.0	201.0	232.0	262.0	297.0	388.2
R. kuleszae	2008	–	4.0	11.0	30.0	45.0	59.0	65.0	70.0	72.0	78.0	–	–	–	–	–	–	–	–	–	–	–	–	240.2
	2009	9.5	23.0	50.0	65.0	83.0	97.0	105.0	113.0	129.0	147.0	162.0	239.0	303.0	338.0	351.0	363.0	–	–	–	–	–	–	268.7
	2010	5.0	14.0	25.0	36.0	41.0	51.0	79.0	117.0	131.0	150.0	151.0	152.0	160.0	171.0	233.0	290.0	358.0	403.0	411.0	417.0	425.0	437.0	491.2
R. caesius	2008	–	6.0	12.0	19.0	23.0	24.0	25.0	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	80.8
	2009	3.5	9.5	12.0	14.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	25.0	30.0	–	–	–	–	–	–	–	–	74.8
	2010	7.5	9.0	18.0	30.0	35.0	43.0	47.0	54.0	65.0	72.0	75.0	80.0	83.0	86.0	103.0	119.0	131.0	140.0	151.0	159.0	163.0	170.0	186.7

DISCUSSION

Generally *Rubus* species growing in Central Europe have been relatively well recognised and their systematic evaluation has been conducted in almost all countries of this region, but their ecological and biological properties, with the exception of few species, have not been studied in depth (Zieliński 2004, Trávníček and Zázvorka 2005, Žila and Weber 2005, Weber 2007, Lepši and Lepši 2009). Certainly such data could help us understand biogeographical processes, distribution dynamics, and migration of these *Rubus* species. A thorough evaluation would help us identify native *Rubus* species for cultivation as ornamental, herbal or fruit-growing plants.

Especially in recent years brambles have become very attractive for consumers, because of the potential significance of their fruits and leaves in the prevention and treatment of lifestyle diseases. All *Rubus* species are important sources of flavonoids and other phenolics. There is a need to recognise the chemical composition of all native species of this genus. At the same time, indigenous *Rubus* species should be studied to better understand their habitat conditions, growth dynamics, flowering and fruiting. Such an evaluation would allow us to select the most valuable group of species with respect to medicinal properties as well as their utility in cultivation. Since 2008 we have just carried out field investigations on native *Rubus* species cultivated in the Dendrological Garden of the Poznań University of Life Sciences. We are going to evaluate *Rubus* species for their growth and fruiting every year. Then selected species will be analysed in reference to their phenolics content in collaboration with the Poznań University of Medical Sciences. We would like to recommend new *Rubus* species worthy of introducing into commercial cultivation.

We want also to emphasize the fact that in the case of traditionally grown *Rubus* species, such as *R. idaeus*, their wild forms are genetic resources that can be repeatedly investigated for useful traits. For example Marshall et al. (2001), as well as Graham et al. (2003) proved that wild raspberry populations are more genetically diverse than cultivars and furthermore that the natural gene flow between these plant groups practically does not occur.

In our earlier studies on *Rubus* species from the *Corylifolii* section (Kluza-Wieloch and Maciejewska-Rutkowska 2009), in spite of the close relationship between the species, we noticed the differences in the seasonal rhythm of individual taxa. Similarly, in the current study on species with different systematic positions within *Rubus*, the pattern of phenological phenomena varied depending on individual species and did not reflect the taxonomic division of this genus.

Although two observed alien species naturalized in Poland, i.e. *R. allegheniensis* and *R. canadensis*, originated from the eastern part of North America (Zieliński 2004), their life cycles were different. Usually leaves of *R. allegheniensis*, a species native to more southern regions, developed latest of all, while the more northerly adapted *R. canadensis* not surprisingly started its vegetative development significantly earlier, as soon as temperatures warmed. However, both species are poorly adapted to our area.

CONCLUSIONS

Weather factors distinctly influenced the course of development phases in all 10 observed *Rubus* species. Drought during the growing season caused flowering disorders, withering of fruit, earlier overcolouring and fall of leaves. However, *R. idaeus* and *R. fabrimontanus* successfully completed their entire fruiting cycle every year of observations and seemed to be the best adapted species for fruit production. Furthermore, *R. fabrimontanus*, together with *R. kuleszae* and *R. praecox*, were the most vigorous species with reference to shoot growth.

Phenology was variable depending on the individual species and did not reflect the intertaxonomic division of the genus *Rubus*. However, *R. idaeus* had a visibly shorter cycle of flowering and fruiting. The differences in phenological stages among the other species were not so essential.

The tops of annual stems in all the species except for *R. idaeus* rooted in autumn in response to the shortening day length. It seemed to be a significant strategy of the species dispersal, as it was often noted that some species did not ripen their fruit before winter.

REFERENCES

Abbate G., Bonacquisti S., Scassellati E. (2002): Morphological study of three taxa of the genus *Rubus* L. sect. *Rubus* (Rosaceae) in Western Central Italy. Plant Biosyst. 136, 3: 321-330.

Bijlsma R.-J., Haveman R. (2007): *Rubus canduliger,* a new regional species from the Netherlands, with notes on the range structure and dynamics of brambles (*Rubus,* Rosaceae). Folia Geobot. 42: 315-329.

Graham J., Marshall B., Squire G.R. (2003): Genetic differentiation over a spatial environmental gradient in wild *Rubus idaeus* populations. New Phytol. 157: 667-675.

Gudej J., Tomczyk M. (2004): Determination of flavonoids, tannins and ellagic acid in leaves from *Rubus* L. species. Arch. Pharm. Res. 27, 11: 1114-1119.

Kluza-Wieloch M., Maciejewska-Rutkowska I. (2009): Rhythmic development of some native species of blackberries (*Rubus* L., *Corylifolii*, Rosaceae) from the collection of Dendrological Garden of University of Life Sciences in Poznań. Herba Pol. 55, 3: 38-46.

Kollmann J., Steinger T., Roy B.A. (2000): Evidence of sexuality in European *Rubus* (Rosaceae) species based on AFLP and allozyme analysis. Am. J. Bot. 87, 1: 1592-1598.

Kraft T., Nybom H., Werlemark G. (1996): DNA fingerprint variation in some blackberry species (*Rubus* subgen. *Rubus*, Rosaceae). Plant Syst. Evol. 199: 93-108.

Lawrence A.A., Campbell Ch.S. (1999): Phylogeny of *Rubus* (Rosaceae) based on nuclear ribosomal DNA

internal transcribed spacer region sequences. Am. J. Bot. 86, 1: 81-97.

Lepši M., Lepši P. (2009): *Rubus silvae-norticae*, a new species from Bohemia, Austria and Bavaria and the significance of brambles for regional migrations. Preslia 81: 43-62.

Łukasiewicz A. (1984): Potrzeba ujednolicenia metody fenologicznej w polskich ogrodach botanicznych i arboretach. Wiad. Bot. 28, 2: 153-158.

Marshall B., Harrison R.E., Graham J., McNicol J.W., Wright G., Squire G.R. (2001): Spatial trends of phenotypic diversity between colonies of wild raspberry *Rubus idaeus*. New Phytol. 151: 671-682.

Matuszkiewicz W. (2006): Przewodnik do oznaczania zbiorowisk roślinnych Polski. Wyd. Nauk. PWN, Warszawa: 103-104, 141-156.

Matzke-Hajek G. (1999): Complementary investigation on taxonomy of *Rubus* species of section *Corylifolii* in West Germany and adjacent countries. Feddes Repert. 110, 3-4: 161-172.

Milivojevič J., Maksimovič V., Nikolič M., Bogdanovič J., Maletič R., Milatovič D. (2007): Chemical and antioxidant properties of cultivated and wild *Fragaria* and *Rubus* berries. J. Food Qual. 34: 1-9.

Tomlik-Wyremblewska A., Zieliński J., Guzicka M. (2010): Morphology and anatomy of blackberry pyrenes (*Rubus* L., Rosaceae). Elementary studies of the European representatives of the genus *Rubus* L. Flora 205: 370-375.

Trávniček B., Zázvorka J. (2005): Taxonomy of *Rubus* ser. *Discolores* in the Czech Republic and adjacent regions. Preslia 77, 1: 1-88.

TuTiempo.net – El Tiempo. Available on line at http// www.tutiempo.net/en/Climate/Poznan/htm; cited on 30 Oct. 2011.

Venskutonis P.R., Dvaranauskaite A., Labokas J. (2007): Radical scavenging activity and composition of raspberry (*Rubus idaeus*) leaves from different locations in Lithuania. Fitoterapia 78: 162-165.

Weber H.E. (1996): Former and modern taxonomic treatment of the apomictic *Rubus* complex. Folia Geobot. Phytotaxon. 31: 373-380.

Weber H.E. (1999): The present state of taxonomy and mapping of blackberries (*Rubus*) in Europe. Acta Bot. Fenn. 162: 161-168.

Weber H.E. (2000): On the research of genus *Rubus* in the Czech Republic. Preslia 72, 2-4: 231-239.

Weber H.E. (2007): A new *Rubus*-species in Lower Saxony. Hercynia 40, 2: 279-283.

Zieliński J. (2001): *Rubus* L. In: Atlas rozmieszczenia roślin naczyniowych w Polsce. Eds A. Zając, M. Zając. Pracownia chorologii komputerowej Instytutu Botaniki Uniwersytetu Jagielońskiego, Kraków.

Zieliński J. (2004): The genus *Rubus* (Rosaceae) in Poland. Pol. Bot. Stud. 16: 1-300.

Zieliński J., Kosiński P., Tomaszewski D. (2004): *Rubus lucentifolius* (Rosaceae), a new species of bramble from Poland. Pol. Bot. J. 49, 1: 5-9.

Žila V., Weber H.E. (2005): A new species of *Rubus* from Bavaria, Bohemia and Austria. Preslia 77, 4: 433-437.

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