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Ribes Bloom Phenology: Sections *Botrycarpum* and *Ribes*

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Abstract

The USDA Agricultural Research Service *Ribes* L. genebank at the National Clonal Germplasm Repository (NCGR) in Corvallis, Oregon, was surveyed to determine timing of first bloom. Accessions of 106 black and 53 red currant genotypes were observed weekly during the springs of 1999, 2001, 2003, 2007, and 2008. Calendar dates were recorded for first, full, and last bloom. The dates were converted to growing degree-day (GDD) values using a heat accumulation model set to begin on 1 January at a base temperature of 5° C. Mean first bloom for red currants (section *Ribes*) occurred at 247 GDD, and for black currants (section *Botrycarpum*) at 256 GDD. Significant interaction was observed between botanical section and year, although genotypes within a section flowered in the same relative order. This report documents cultivars with blooming phenologies suited for a range of production goals and environments. Black currants, such as *R. nigrum* L. 'StorKlas' and 'Ben Tirran,' and red currants, *R. ×koehnianum* Jancz. 'Mulka' and *R. rubrum* L. 'Moore's Ruby,' bloom in late spring and avoid early-season frosts. These cultivars can be grown in locations with long, cool springs. Early-flowering cultivars, such as *R. nigrum* 'Risager' and *R. rubrum* 'Wilder,' may be suited for environments where heat accumulates rapidly at the onset of summer. Genotypes from both sections show potential for growers to incorporate cultivars which flower in succession from early to late spring.

Cultivation of currants (*Ribes* sections *Ribes* and *Botrycarpum*) is common in Europe. Fruits of these species are used in processed products such as jams, jellies, juices, teas, and liqueurs, and as garnishes for culinary purposes (9). Most North American consumers are less familiar with currant fruits than with other berry crops; yet, niche market opportunities exist for *Ribes* production in North America where populations of strong European heritage are located (6, 7).

The flowering phenology of currants has been inadequately documented for North American production (2). Timing of bloom is one of many factors identifying appropriate genotypes for cultivation in specific production regions (13, 17, 18). The seasonality of bloom impacts the efficacy of pollinators, and consequently fruit size and yield (19). Several black currant cultivars are self-fruitful and may not necessarily benefit from the presence of pollinizers; however, cross-pollination has been demonstrated to maximize fruit set (22). Planting 1 to 2% of the field with compatible pollinizer cultivars promotes cross-pollination and may enhance berry yields, regardless of self-compatibility (1). Overlapping bloom periods determine suitable pollinizers for an orchard.

Plant breeders consider flowering phenology when choosing parents for planned crosses. Phenological traits are quantitative characteristics; thus, documentation of blooming period may reveal suitable cultivars as the basis for improvement in a given environment (3). In several commercially important growing regions, the use of late-flowering parents is a way to confer frost-avoidance to progeny and improve cultivar performance (13). Past breeding efforts have incorporated the late-flowering species *R. multiflorum* Kit ex Schult. into commercial red currant germplasm. Red-fruited cultivars *R. ×koehnianum* 'Rondom' and 'Mulka' exhibit strong frost avoidance mechanisms and were developed using *R. multiflorum* as a parent

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(2, 11). By contrast, early-blooming parents may be desirable for regions where heat accumulates rapidly at the beginning of the growing season. Phenological studies often observe the calendar date of bloom (12). However, a principal factor influencing spring phenology is the occurrence of warm air temperatures rather than photoperiod or calendar dates (8, 10, 15, 21). Because year-to-year variation in weather patterns influences flowering phenology, degree-day models help to predict plant development (16). European studies have examined bloom phenology for a few select *Ribes* species (8, 13, 16, 17, 18). Comprehensive data do not yet exist for *Ribes* in North America.

The primary objective of this study was to document the range of GDD necessary to initiate bloom for black currant (*Ribes* section *Botrycarpum*) and red currant (*Ribes* section *Ribes*) accessions grown under field conditions at the USDA-ARS NCGR in Corvallis, Oregon. These phenological results will identify cultivars and pollinizers adapted to cool spring temperatures and will suggest parental stock for North American black and red currant breeding programs.

Materials and Methods

This study was conducted in the *Ribes* field genebank (lat. 44.55 N, long. 123.23 W, elev. = 70 m) at the USDA-ARS NCGR in Corvallis, Oregon. Two plants of each accession were represented at each field location and were considered together as an observational unit. Certain accessions were represented in more than one field location, thereby serving as replicate observations of the same genotype in a given year. The field was surveyed at least once per week during the springs of 1999, 2001, 2003, 2007, and 2008 by staff at the NCGR. Phenological data were recorded according to the calendar date of each field survey. Three phenophases were observed in the study. First bloom was recorded once any single flower was observed with open petals. *Ribes* plants have several flowers per raceme that bloom over a period of weeks, and the last flower to open is often preceded by the senescence of the first flowers on the raceme. Because of this asynchronous blooming pattern, the plant was considered at full bloom when an estimated 50% of the flowers had opened. Last bloom was determined when 75% of the flowers had visibly brittle stigmas and petals of the latest flowers had lost vibrant color. Because all accessions had at least three years of first bloom observation, this criterion served as the point of comparison between cultivars in this study.

An online degree-day calculator, courtesy of the Oregon State University Integrated Plant Protection Center, was used to retrieve weather data and calculate GDD values for each year of the study (5). Temperature data originated from the US Bureau of Reclamation, Corvallis, Oregon, AgriMet weather station, which is located six miles from the field study site and shares similar agroecological conditions (20). These data were converted to GDD values and statistically analyzed using analysis of variance (ANOVA) (S+, Insightful Corporation, Seattle, WA). Growing degree-days were calculated by summing the daytime high plus the nighttime low, then dividing by two to produce the mean daily temperature. From this value, the base temperature of 5° C was subtracted. Negative values were rounded to zero, whereas positive values were added to the running total to determine the number of GDD accumulated over the course of the season. Based on the findings of Heikinheimo and Lappalainen (8), the model was set to begin each year on 1 January, and in each year the survey was terminated by 30 June, by which time all *Ribes* in the genebank had reached last bloom.

Genotypes of black and red currants were separated into the respective taxonomic sections *Botrycarpum* and *Ribes*. After performing ANOVA, the Fisher's LSD multiple comparison technique was applied to identify cultivar pairs that differed in timing of first bloom. The pooled estimate of the standard deviation was calculated for both sections using the formula:

$$sp = \sqrt{(\Sigma((n_i-1)*sd_i)) \div d.f._t}$$

Where n_i = the number of samples for the ith group, and I = the total number of samples (14). Pooling the estimate of standard deviation weighted the variances to correct for unequal distribution of observations and accessions within each section and year. Data matrices were constructed using Microsoft® Office Excel (Microsoft Corporation, Redmond, WA) to provide the p-values and confidence intervals of all possible pair-wise comparisons within each section. Indicator variables 1 and 0 were used to designate significant and non-significant comparisons, respectively, at 95% confidence.

Results and Discussion

Timing and duration of bloom are represented for 159 field-grown genotypes representing sections *Botrycarpum* and *Ribes*. These phenophases are graphically presented so that growers and plant breeders may gain better insight on the overall duration of bloom in the two botanical sections.

Calendar date of first bloom was not linearly correlated with the number of GDD observed at first bloom (Fig. 1). ANOVA procedures showed strong year ($F_{4,48}$ = 695, $p < 0.001$) and accession ($F_{158,48}$ = 6.85, $p < 0.001$) effects on timing of first bloom, but no interaction between the two factors ($F_{4,158}$ = 0.937, $p = 0.64$; Table 1a), suggesting that throughout the study, cultivars bloomed in similar relative order. A second ANOVA yielded significant year ($F_{4,759}$ = 340, $p < 0.001$) and section ($F_{1,759}$ = 14.6, $p < 0.001$) effects, as well as strong year × section interactions ($F_{4,1}$ = 11.6, p <0.001; Table 1b and Fig. 2). Therefore we looked at differences within each section.

In each year, a broad overlap of phenological events was evident. Section *Ribes* had a mean first bloom of 247 GDD (95% CI: 241, 253 GDD). Section *Botrycarpum* (mean 256 GDD, 95% CI: 252, 260 GDD) had a later mean bloom timing than section *Ribes*, although this depended on the year (Fig. 2).

First bloom characteristics for 159 *Ribes* genotypes were statistically analyzed, allowing 12,561 pair-wise comparisons of first bloom to be made between the accessions. In most practical applications for plant breeders and growers, the comparisons of interest involve accessions within a botanical section. When narrowed to fit this criterion, 6,943 comparisons were made. Of these, the Fisher's LSD pairwise comparison analysis individually recognized 834 significant combinations at 95% confidence. Due to the large variance associated with year effects, confidence intervals for individual accessions were wide. Nonetheless, the comparisons identified several sets of cultivars that did not overlap in timing of first bloom, after accounting for year effects, indicating statistically divergent timing of first bloom.

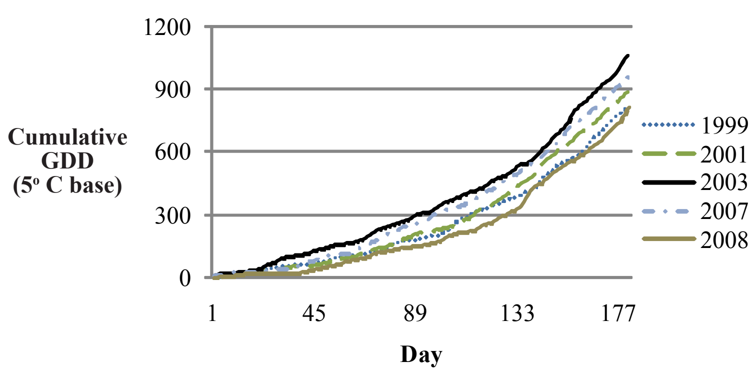


Fig. 1. Non-linear accumulation of growing degree-days at Hyslop Farm, Corvallis, Oregon, on a calendar date scale.

Table 1. Two-way analysis of variance. a) growing degree-days of first bloom ~ Year + Accession + Year × Accession; b) growing degree-days of first bloom ~ Year + Section + Year × Section.

a)

	d.f.	SS	MS	F-statistic	*p*
Year	4	1287856	321964.1	695	<0.001
Accession	158	501027	3171.1	6.85	<0.001
Year × Accession	538	233426	433.9	0.937	0.64
Residuals	48	22233	463.2		

b)

	d.f.	SS	MS	F-statistic	*p*
Year	4	1287856	321964.1	340	<0.001
Section	1	13850	13850.3	14.6	<0.001
Year × Section	4	44040	11010.1	11.6	<0.001
Residuals	739	698796	945.6		

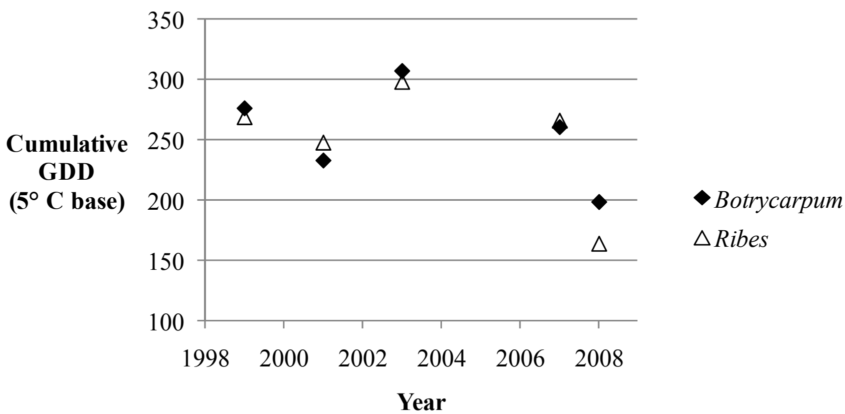


Fig. 2. Mean first bloom for *Ribes* sections *Botrycarpum* and *Ribes* showing year × section interaction. Data collected from Corvallis, Oregon.

Section *Botrycarpum*. Black currants exhibited a broad flowering window, with several early and late cultivars. In total, 725 of 5,565 comparisons showed significant differences of first bloom. Approximately half of the significant comparisons involved the seven earliest black currant genotypes, all of Asiatic or Scandinavian origin. An unnamed genotype of *R. nigrum* subsp. *sibiricum* W. Wolf (PI 556419) was the earliest among the *Botrycarpum*, reaching first bloom at a mean of 185 GDD (95% CI: 63, 306 GDD; Fig. 3). This genotype was significantly earlier than 80 black currants, including those with a mean first bloom value greater than 246 GDD. The latest black currant was *R. bracteosum* Dougl. (PI 617717), which bloomed significantly later than 95 *Botrycarpum* genotypes and reached first bloom at a mean 343 GDD (95% CI: 241, 446 GDD).

The relative order of black currant cultivars observed in this study corroborates European documentation of black currant cultivar bloom characteristics (4, 13, 18). In the United Kingdom, efforts have been underway for more than three decades to release late-flowering replacement cultivars for frost susceptible industry standard juice varieties (2). By measure of late-flowering in Corvallis, Oregon, the 'Ben' series, released from the Scottish Crop Research Institute, has effectively achieved this objective. The cultivars 'Ben Sarek,' 'Ben Connan,' 'Ben Lomond,' 'Ben Nevis,' 'Ben More,' 'Ben Alder' and 'Ben Tirran' ranked among the latest 69% of the black currant genotypes in the study, whereas the older British black currants 'Wellington XXX' and 'Baldwin'

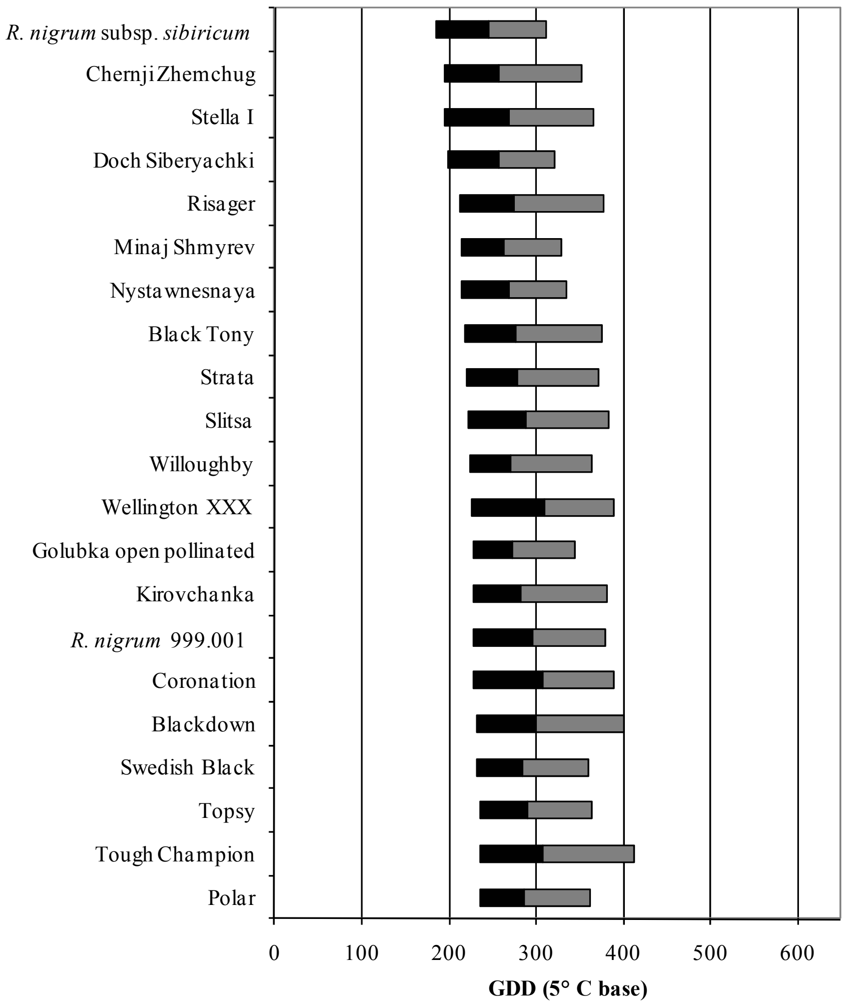


Fig. 3. Black currant (*Ribes* section *Botrycarpum)* phenological development plotted in mean growing degree-days for 1999, 2001, 2003, 2007, 2008, observed in Corvallis, Oregon. Black bar indicates the period from first bloom; gray bar indicates full to last bloom. Genotypes are ordered by lowest to highest mean GDD of first bloom.

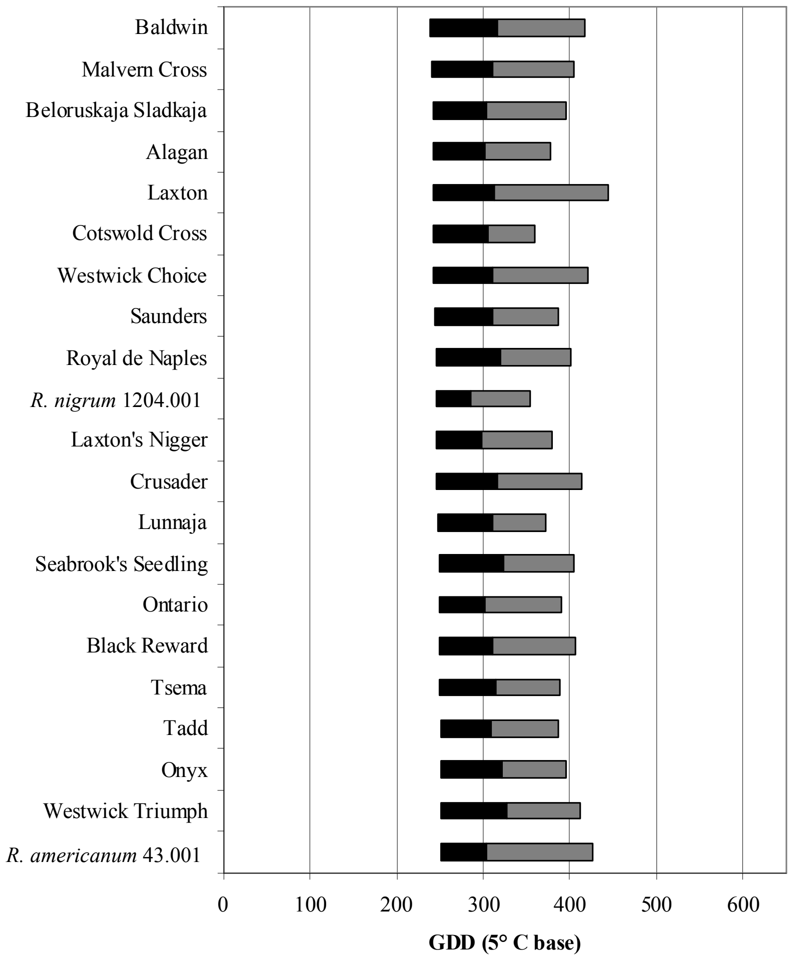
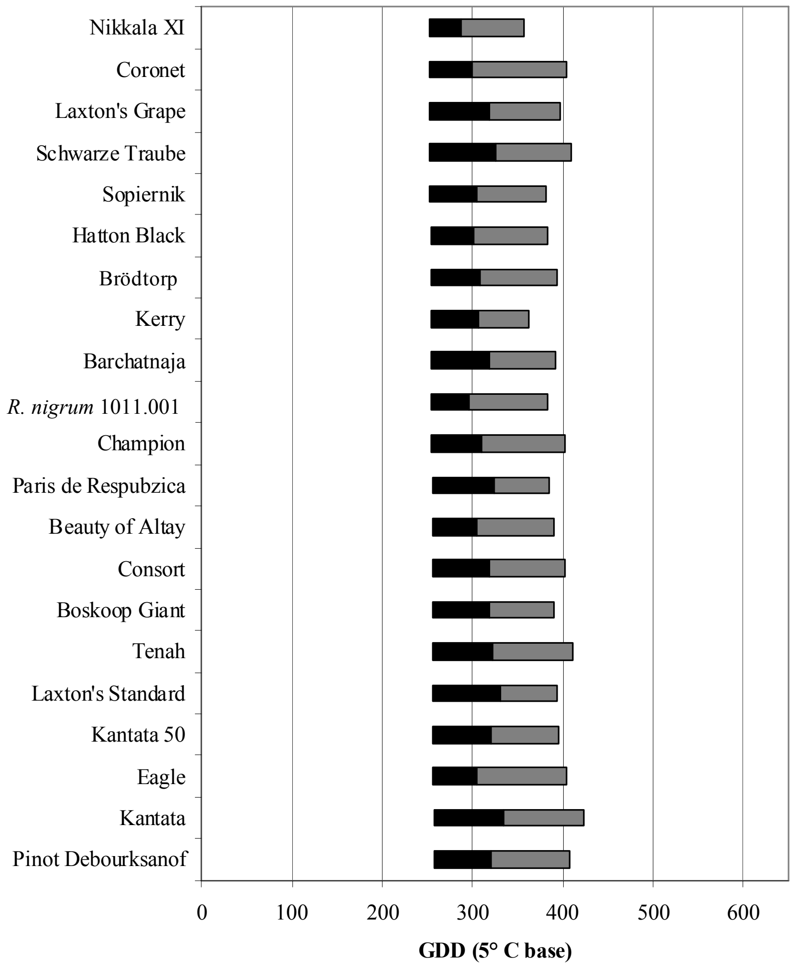


Fig. 3. (Continued)

ranked below the 25th percentile in order of black currant first bloom, indicating their early phenology.

Section *Ribes*. Of the 1,378 pair-wise comparisons within section *Ribes*, analysis of the red, white, and pink-fruited currants yielded 109 significant differences in the mean GDD of first bloom. The three earliest cultivars showed significant differences with the 12 latest cultivars, whereas the three latest cultivars were significantly later than the 12 earliest cultivars (Fig. 4). These phenological data are in close agreement with late-flowering red currant cultivars identified in Romania by Mladin and Mutafa (13). An exception is 'Raby Castle,' which in Romania was considered late-flowering. The present study shows an intermediate bloom timing of 'Raby Castle,' differing only from 'Mulka,' the latest-flowering red currant in the present study. Compared to Polish observations, cultivars 'Detvan,' 'Primus' and 'Blanka' bloomed in similar relative order (17). 'Tatran' and 'White Versailles' bloomed relatively late in Corvallis; however, no significant pair-wise differences were identified in mean



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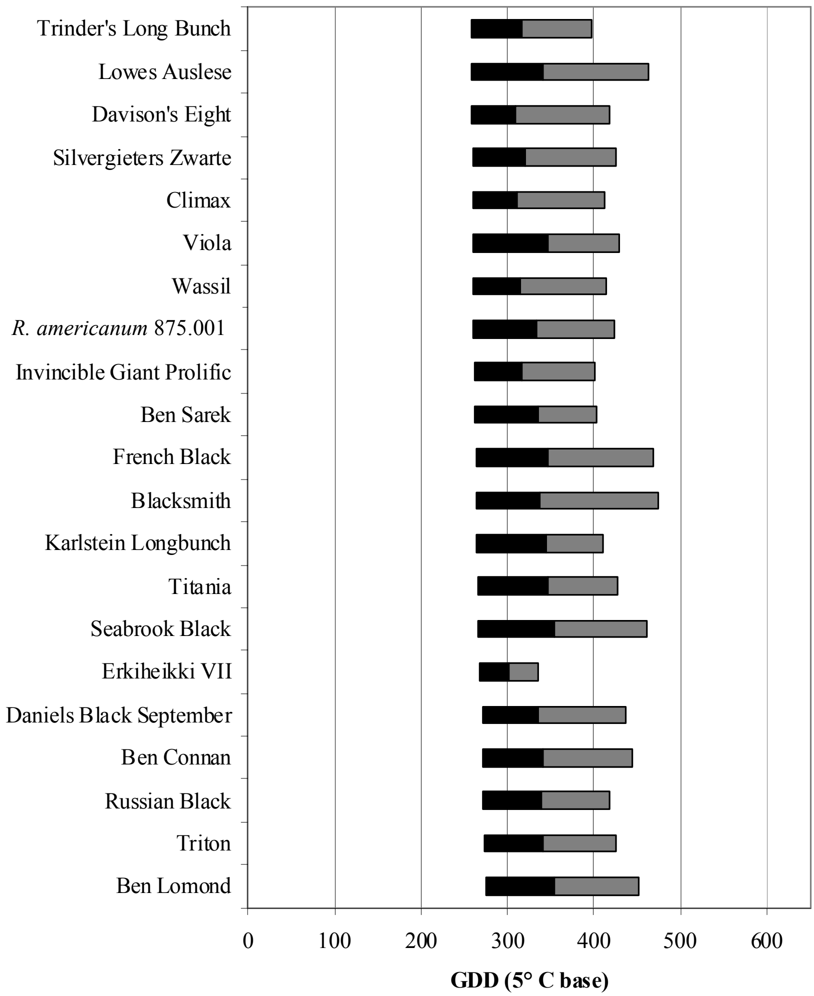
GDD of first bloom among these five cultivars. Early and late-blooming cultivars exist for the red, pink, and white fruited variants of section *Ribes*.

Conclusions. This study provides information designed to facilitate black and red currant cultivar selection based on first bloom. *Ribes* cultivars are recognized for timing of early and late-season bloom phenologies. Considerable overlap was observed between and within the sections *Botrycarpum* and *Ribes*.

With a knowledgeable prediction of the blooming period, fruit producers can work to maximize fruit set through implementation of cultural practices, for example by choosing genotypes adapted to local environmental conditions, or by setting out beehives at an appropriate time to promote a high level of cross-pollination. In regions with long, cool springs, frost risks can be reduced by selection of late-flowering cultivars. The observed inconsistency in the number of calendar days and GDD necessary to initiate first bloom was due to variable weather patterns from year to year. In 2003, the warmest spring of the survey, plants bloomed after a relatively



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high number of GDD had accumulated. In contrast, the coolest spring of 2008 displayed the accumulation of the fewest GDD before first bloom. This observation suggests that bloom timing is contingent on more factors than simply spring heat accumulation. However, daytime air temperature was the single most important influence on flowering in diverse plant taxa (21). Despite the inconsistent response of sections *Botrycarpum* and *Ribes* to rapid or slow spring heat accumulation, growers can apply these data to predict flowering based on the weather patterns in the months prior to bloom.

Because flowering responses are under genetic control, these data suggest parents suitable for either early- or late-flowering breeding objectives. The late-flowering *R. nigrum* 'Öjebyn' and 'Amos Black' have been used as parents to produce late-flowering Scottish black currant cultivars and have potential to donate frost-avoidance mechanisms

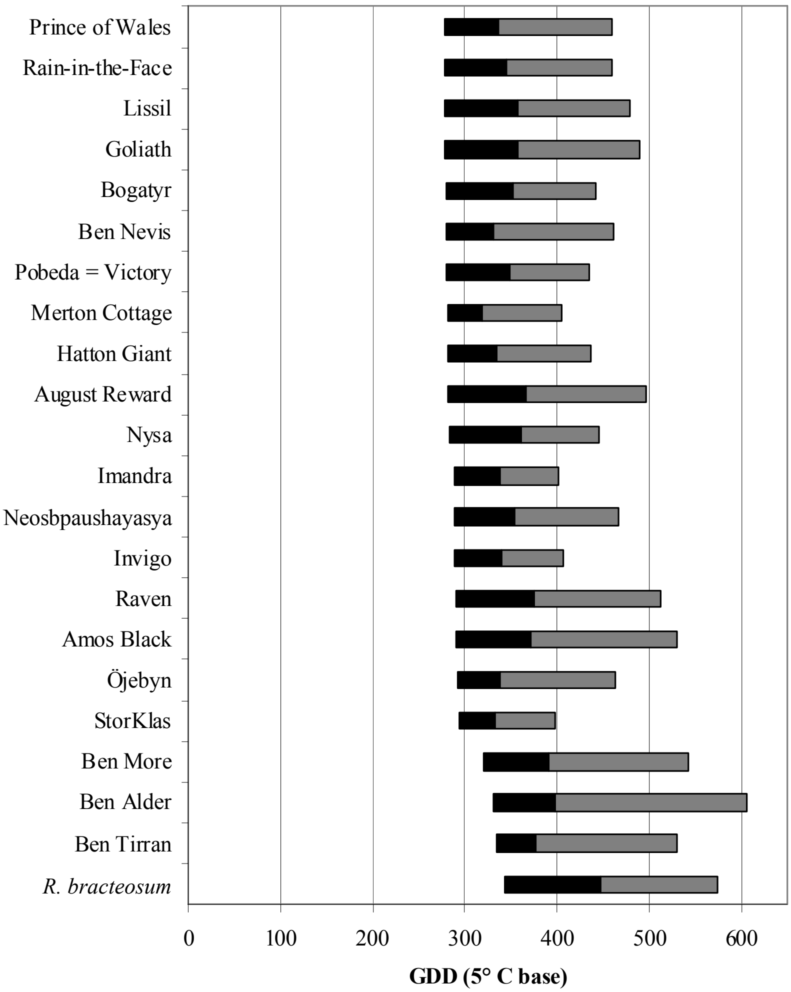

Fig. 3. (Continued)

to future progeny. Intra-sectional hybrid red currant cultivars 'Mulka' and 'Rondom,' selected in northern European countries where late-spring frosts are frequent, have also donated late-flowering characteristics to their offspring.

These data establish phenological records for black and red currant cultivars growing in Corvallis, Oregon. Additional years of observation may decrease the year-to-year variance of the onset of bloom and will also provide comparisons of other phenophases to help growers identify appropriate cultivars for their particular growing regions.

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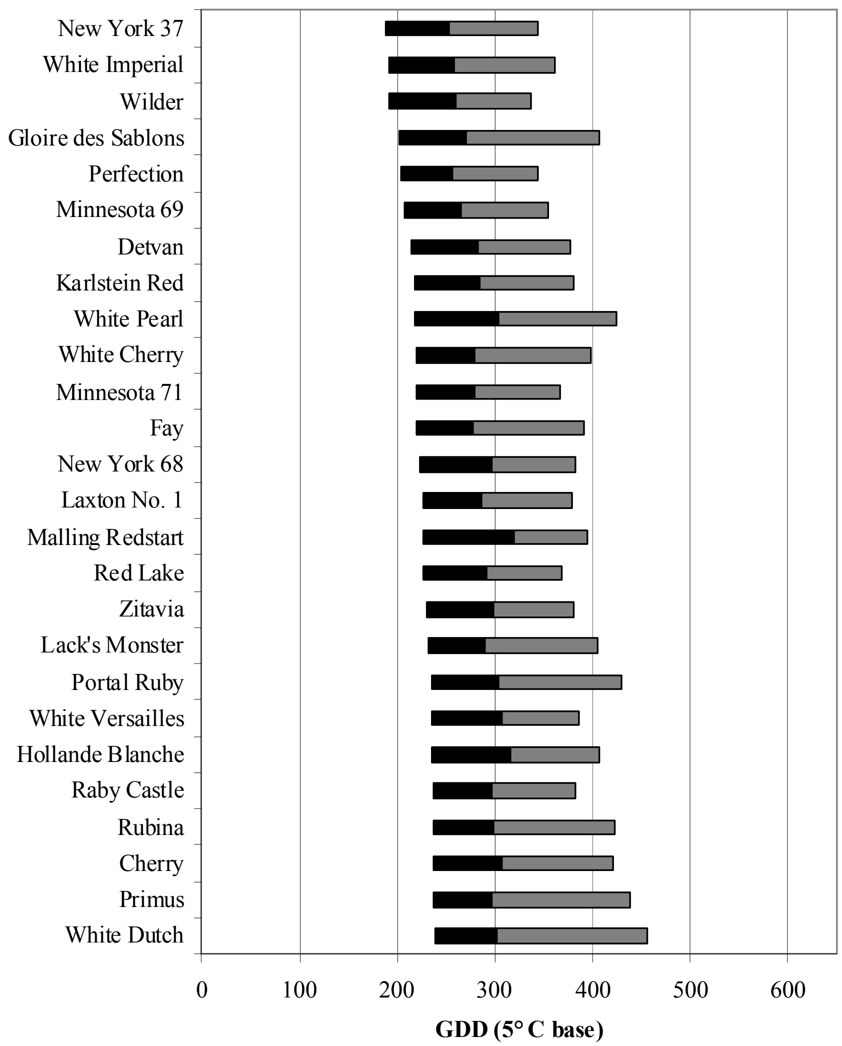
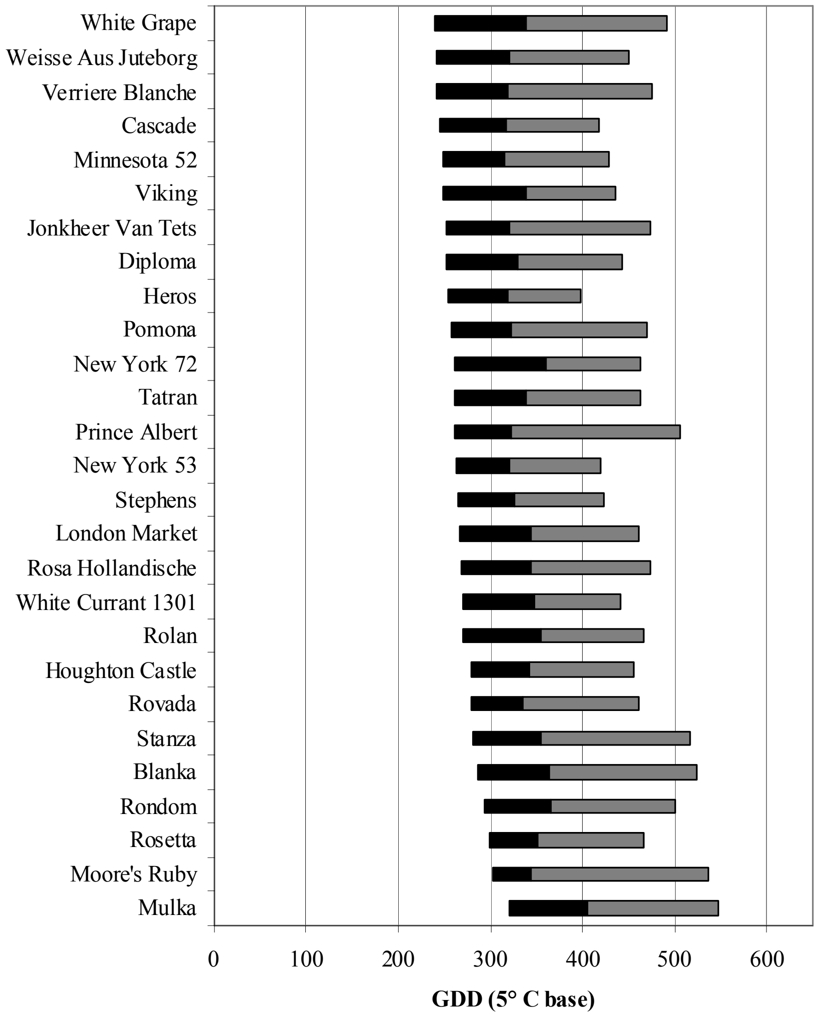


Fig. 4. Red currant (*Ribes* section *Ribes*) phenological development plotted in mean growing degree-days for 1999, 2001, 2003, 2007, 2008, observed in Corvallis, Oregon. Black bar indicates the period from first bloom to full bloom; gray bar indicates full to last bloom. Genotypes are ordered by lowest to highest mean GDD of first bloom.



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