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ORIGINAL RESEARCH PAPER in HORTICULTURAL PLANTS

# Nectar Production and Spectrum of Insect Visitors in Six Varieties of Highbush Blueberry (*Vaccinium corymbosum* L.) in SE Poland

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## Abstract

The attractiveness of plants to pollinators depends strongly on flower rewards, especially nectar and pollen. Nectar mass, sugar concentration, and sugar mass are known to influence the spectrum and abundance of insect visitors. Respective data on nectar secretion in highbush blueberry (*Vaccinium corymbosum*) under the climatic conditions of Poland are scarce. This study was conducted in 2002–2005 to assess flower abundance, nectar production, and insect visitors in six varieties of *V. corymbosum* in Niemce, SE Poland. Flower abundance ranged from  $1.63 \pm 0.64$  ('Darrow') to  $4.07 \pm 0.95$  in thousands of flowers per shrub ('Northland'). Nectar mass, sugar concentration, and nectar sugar mass increased with flower age, peaking between the sixth and ninth day. Significant differences in nectar characteristics occurred between years and between varieties. 'Bluecrop' and 'Darrow' produced the largest nectar mass ( $19.08 \pm 7.09$  and  $16.60 \pm 8.31$  mg nectar per flower, respectively) and nectar sugar mass per flower ( $6.39 \pm 1.52$  and  $5.76 \pm 1.51$  mg sugar per flower, respectively). The estimated sugar yield in the studied *V. corymbosum* varieties ranged from  $9.4 \pm 3.3$  to  $20.7 \pm 3.8$  g sugar per shrub ('Croatan' and 'Bluecrop,' respectively). Regarding insect visitors, only honey bees and bumble bees were observed. Honey bees comprised 81%–98% of the total number of observed insect visitors. Highbush blueberry, due to abundant blooming and high per-flower sugar yield, is thus a good source of nectar sugars for honey bees.

## Keywords

highbush blueberry; nectar production; nectar sugars; insect visitors; honey bees

## 1. Introduction

It has been estimated that over 75% of the globally most important food crops depend, to some extent, on animal pollination (Klein et al., 2007), and insect pollination was shown to enhance fruit and seed quantity and quality (Bisui et al., 2020; Bommarco et al., 2012; Castle et al., 2019; Garratt et al., 2014; Pereira et al., 2015; Sushil et al., 2013). However, over the past decades, severe losses in insect pollinator numbers and diversity have been reported (Cameron et al., 2011; Kevan & Phillips, 2001; Rhodes, 2018; Antoń & Denisow, 2018). The main causes of this phenomenon include agricultural intensification, spreading of insect pathogens, habitat loss, and shortage of food resources (Dance et al., 2017; Fürst et al., 2014; Jachula, Denisow, & Wrzesień, 2018; Łoś et al., 2020; Wrzesień et al., 2016; Xiao et al., 2016), and it can reduce agricultural profitability (Gallai et al., 2009; Winfree et al., 2011) and threatens overall biodiversity (Brodie et al., 2014; Potts et al., 2010).

Nectar is a floral reward that mediates mutualistic relationships between the majority of angiosperms and visiting insects (Bożek, 2019; Nepi et al., 2018; Palmer-Young

et al., 2019); it is an aqueous solution of sugars and other minor constituents, e.g., amino acids, proteins, alkaloids, phenolics, and metal ions (Nicolson & Thornburg, 2007; Roy et al., 2017) and is considered an important source of energy to pollinators (Hayashi et al., 2016; Somme et al., 2015). Nectar secretion patterns, sugar concentration, nectar sugar mass, and nectar chemical composition (primarily sugar and amino acid composition) are crucial factors affecting insect visitor guilds as well as frequency and duration of visits to flowers (Brown & Brown, 2020; Jachuła et al., 2019; Nepi et al., 2018; Shackleton et al., 2016; Strzałkowska-Abrańek, 2019).

The reproductive success of entomophilous plants species depends on insect activity which is influenced by nectar availability (Denisow et al., 2016, 2018; Heil, 2011; Liu et al., 2015; Zhao et al., 2014). Studies on nectar production may thus be useful to estimate a plant's attractiveness to pollinators (Masierowska & Piętko, 2014; Nagy-Déri et al., 2013; Schmidt et al., 2015), which in turn affects yield and quality of fruit and seeds (Bożek, 2012; Quinet et al., 2016), even in self-fertile taxa (de O. Milfont et al., 2013; Denisow, 2002).

Highbush blueberry (*Vaccinium corymbosum*) has become a popular commercial crop in Europe. This species has attracted attention due to its pleasantly sweet fruits which are also a source of biologically active compounds, especially antioxidants (Cardenosa et al., 2016; Pervin et al., 2016). Poland is one of the leading producers of blueberries – in 2019, total fruit yield exceeded 25,000 tons, and approximately 6,700 tons of fruit were exported, predominantly to countries of the European Union (Statistics Poland, 2019). However, data on nectar production by highbush blueberry under the climatic conditions of Poland are scarce and were collected only regarding very young shrubs (Jabłoński et al., 1983).

The present study was conducted to examine nectar production and insect visitors in six varieties of *V. corymbosum*. In particular, (i) diurnal patterns of flowering and flower abundance, (ii) nectar secretion dynamics and nectar sugar yield, and (iii) the spectrum of insect visitors were investigated.

## 2. Material and Methods

### 2.1. Varieties and Study Site

The study was carried out from 2002 to 2005. Six *V. corymbosum* varieties were used, i.e., 'Bluecrop', 'Bluejay', 'Croatan', 'Darrow', 'Northland', and 'Spartan', which had been grown in Niemce (51°22' N, 22°38' E; south-eastern Poland) on a farm covering 0.25 ha, established in 1993. The shrubs had been planted at 2 m × 1 m spacing (5,000 plants/ha). In the local climate, *V. corymbosum* blooms in May or June (Bożek, 2009).

### 2.2. Blooming and Insect Visitors

To assess flower abundance per shrub, each variety's number of flowers per inflorescence ( $n = 15$ ), number of inflorescences per shoot ( $n = 15$ ), and number of shoots per shrub ( $n = 15$ ) were counted and multiplied, respectively. The spectrum and abundance of insect visitors/m<sup>2</sup> were recorded during full flowering. Observations were carried out for 5 min in 1-hr intervals between 6 a.m. and 8 p.m. (GMT + 2 hr) for 3 consecutive days.

### 2.3. Nectar Production

Nectar production was evaluated during full flowering. The pipette method described by Jabłoński (2002) was used. To prevent nectar collection by insect visitors before sampling, inflorescences were covered using tulle bags. The dynamics of nectar production were monitored at different stages of flower development (interval = 1 day) from the budding stage (1–2 hr before flower opening; 'Day 0') until corolla wilting. Nectar was collected using tarred glass pipettes, with 12 replications. A single sample contained nectar of 5–10 flowers. The concentration of sugars (% w/w) in nectar was measured using an Abbe refractometer (Carl Zeiss AG,

**Table 1** Mean air temperatures and precipitation in the study years 2002–2005 and long-term data of 1951–2005 for Niemce, SE Poland.

Month	Year				
	2002	2003	2004	2005	1951–2005
	Air temperature in °C				
April	8.6	6.5	7.9	9.1	7.5
May	17.3	16.3	11.9	13.2	13.0
	Precipitation in mm				
April	18.3	40.7	38.1	18.6	42.0
May	28.6	71.4	38.0	96.0	57.7

Jena, Germany). Using nectar mass and nectar sugar concentration data, nectar sugar mass (at the peak of nectar sugar secretion) was calculated per flower and per shrub.

#### 2.4. Weather Conditions

Meteorological data were collected from a weather station in Niemce. Mean air temperature and precipitation data of 2002–2005 were compared to long-term data collected in 1951–2005 (Table 1). Regarding the month of April, the highest air temperatures were recorded in 2002 and 2005, which exceeded the long-term norm by 1.1 and 1.6 °C, respectively; in these periods, 50% less precipitation than usual was recorded. The highest air temperatures of the month of May were recorded in 2002 and 2003. In May 2005, heavy rainfalls occurred, and precipitation exceeded the long-term norm by more than 60%.

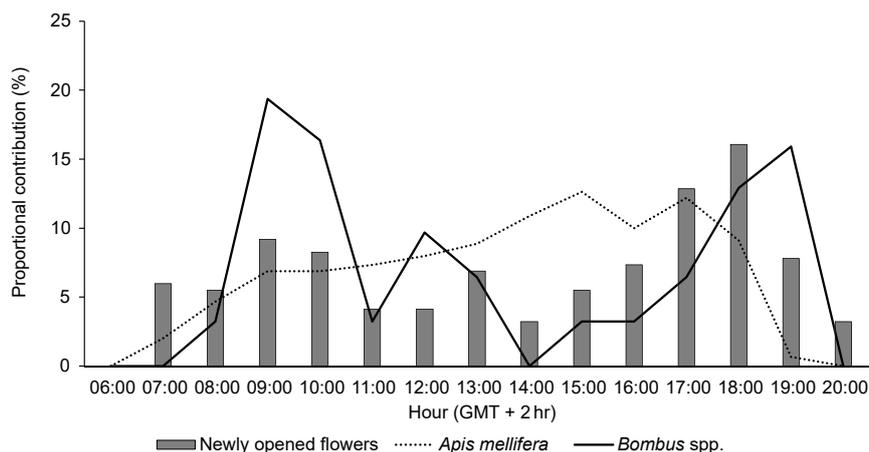
#### 2.5. Data Analyses

Data were analyzed using STATISTICA software v.13.1 (StatSoft Poland, Cracow, Poland). Before analyses, data distribution was tested for normality. Data on nectar mass per flower and sugar mass per flower were  $\log_{10}$ -transformed; data on numbers of flowers per shrub and on sugar mass per shrub were square-root transformed. A one-way analysis of variance was applied to test differences between years and between varieties. Means were compared post hoc using Tukey's HSD test at  $\alpha = 0.05$ .

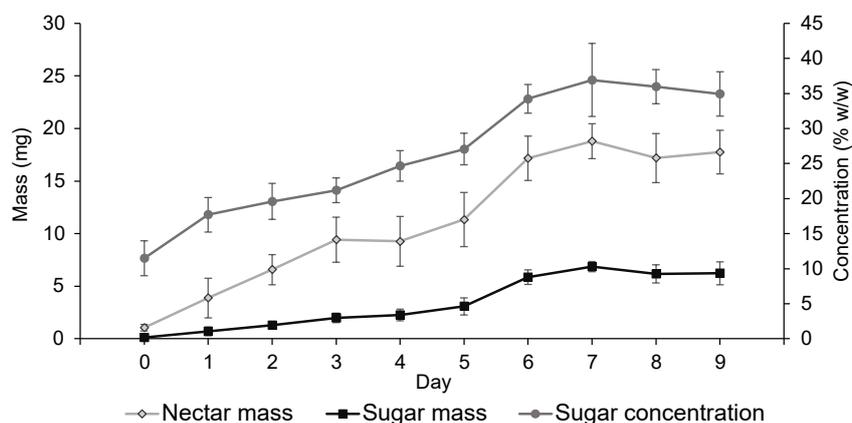
### 3. Results

The diurnal pattern of blooming was similar between varieties; therefore, only that of 'Bluecrop' is described. Bloom development peaked in the evening hours (Figure 1). The number of flower buds that opened between 6 p.m. and 7 p.m. constituted approximately 30% of the total number of flowers developed throughout the day. Both number of flowers per inflorescence and number of inflorescences per shrub differed between years ( $F_{3, 356} = 16.011$ ;  $p < 0.001$  and  $F_{3, 356} = 11.661$ ;  $p = 0.001$ , respectively) and varieties ( $F_{5, 354} = 5.046$ ;  $p < 0.001$  and  $F_{5, 354} = 45.481$ ;  $p < 0.001$ , respectively) (Table 2). Consequently, effects of year ( $F_{3, 354} = 3.457$ ;  $p = 0.019$ ) and variety ( $F_{5, 354} = 35.549$ ;  $p < 0.001$ ) on the number of flowers per shrub were observed. Flowering was most abundant in variety 'Northland' and least abundant in 'Darrow' ( $4.07 \pm 0.95$  vs.  $1.63 \pm 0.64$ , in thousands of flowers per shrub, respectively).

As demonstrated for 'Bluecrop' (Figure 2), nectar mass, sugar concentration, and nectar sugar mass increased throughout flower development and peaked between the sixth and ninth day of the flowers' life-span. Similar patterns were also observed in the other varieties. The mass of produced nectar differed significantly between years ( $F_{3, 284} = 20.464$ ;  $p < 0.001$ ; highest values recorded in 2005) and varieties ( $F_{5, 282} = 31.87$ ;  $p = 0.002$ ; Table 3). The highest per-flower nectar production occurred in 'Bluecrop' and 'Darrow' ( $19.08 \pm 7.09$  mg and  $16.60 \pm 8.31$  mg nectar per flower, respectively). Nectar sugar concentrations differed significantly between years ( $F_{3, 284} = 24.283$ ;  $p = 0.004$ ) and varieties ( $F_{5, 282} = 4.351$ ;  $p < 0.001$ ). Nectar sugar mass was affected by year ( $F_{3, 284} = 6.781$ ;  $p = 0.002$ ) and variety ( $F_{5, 282} = 28.767$ ;  $p < 0.001$ ).



**Figure 1** Diurnal pattern of flowering expressed as numbers of newly opened flowers in 1-hr intervals in relation to the total number of newly opened flowers throughout the day, and diurnal frequency of insect visitors of *Vaccinium corymbosum* 'Bluecrop' observed in Niemce, SE Poland. Shown are mean values over the years of the study.



**Figure 2** Effect of flower age on nectar mass per flower, nectar sugar concentration, and nectar sugar mass per flower in *Vaccinium corymbosum* 'Bluecrop'. Shown are the means  $\pm$  SD (vertical bars) calculated across the years of the study.

'Bluecrop' and 'Darrow' produced the largest sugar mass per flower ( $6.39 \pm 1.52$  mg and  $5.76 \pm 1.51$  mg sugar per flower, respectively). Sugar yield per shrub differed significantly between years ( $F_{3,354} = 5.546$ ;  $p = 0.001$ ) and varieties ( $F_{5,354} = 22.913$ ;  $p < 0.001$ ), and the estimated sugar yield ranged between  $9.4 \pm 3.3$  g and  $20.7 \pm 3.8$  g sugar per shrub, with the highest yield recorded in 'Bluecrop' (Figure 3).

Regarding insect visitors, only honey bees and bumble bees were observed (Figure 4). Depending on the variety, honey bee workers comprised 81%–98% of the total number of insect visitors. Visits of honey bees were distributed evenly throughout the day, while foraging activity of bumble bees peaked in the morning (9 a.m.–10 a.m.) and afternoon hours (6 p.m.–7 p.m.; Figure 1).

#### 4. Discussion

Nectar mass, sugar concentration, and sugar mass in flowers of *V. corymbosum* varied between years of the present study. Variability between years was particularly prominent in 'Darrow'. In this variety, the largest difference in nectar mass was approximately threefold ( $8.41 \pm 2.38$  mg nectar per flower in 2002 and  $25.78 \pm 9.53$  mg nectar per flower in 2005), and the difference in sugar concentration was approximately twofold between years ( $53.7\% \pm 10.5\%$  in 2002 and  $26.8\% \pm 9.8\%$

**Table 2** Flower abundance in six *Vaccinium corymbosum* varieties in 2002–2005 in Niemce, SE Poland.

Variety	Year	No. of flowers/1 inflorescence (mean ± SD)	No. of inflorescences/1 shrub (thous.) (mean ± SD)	No. of flowers/1 shrub (thous.) (mean ± SD)
'Bluecrop'	2002	7.8 ± 3.0a	0.42 ± 0.04ab	3.28 ± 0.31a
	2003	7.5 ± 2.1a	0.37 ± 0.05a	2.80 ± 0.41a
	2004	7.5 ± 1.6a	0.51 ± 0.18b	3.82 ± 1.38b
	2005	7.1 ± 1.5a	0.42 ± 0.07ab	3.01 ± 0.47a
	Mean	7.5 ± 2.1B	0.43 ± 0.11C	3.23 ± 0.86C
'Bluejay'	2002	7.8 ± 1.8b	0.38 ± 0.04a	2.95 ± 0.28a
	2003	6.9 ± 1.9ab	0.38 ± 0.09a	2.61 ± 0.59a
	2004	5.8 ± 1.6a	0.40 ± 0.04a	2.34 ± 0.21a
	2005	6.6 ± 1.6a	0.43 ± 0.07a	2.84 ± 0.45a
	Mean	6.8 ± 1.9AB	0.40 ± 0.06BC	2.69 ± 0.47BC
'Croatan'	2002	7.3 ± 2.2b	0.24 ± 0.04a	1.77 ± 0.25a
	2003	6.1 ± 1.6a	0.26 ± 0.04a	1.60 ± 0.25a
	2004	6.1 ± 1.8a	0.39 ± 0.03b	2.38 ± 0.21b
	2005	6.2 ± 1.6a	0.45 ± 0.06c	2.82 ± 0.40b
	Mean	6.4 ± 1.9A	0.34 ± 0.10B	2.14 ± 0.56B
'Darrow'	2002	8.6 ± 2.2b	0.16 ± 0.03a	1.33 ± 0.23ab
	2003	6.2 ± 2.0a	0.17 ± 0.02a	1.04 ± 0.15a
	2004	6.4 ± 1.5a	0.38 ± 0.10c	2.42 ± 0.63c
	2005	6.6 ± 1.8a	0.26 ± 0.04b	1.70 ± 0.29bc
	Mean	7.0 ± 2.1AB	0.24 ± 0.11A	1.63 ± 0.64A
'Northland'	2002	8.0 ± 1.6a	0.49 ± 0.11a	3.94 ± 0.92a
	2003	7.1 ± 2.1a	0.52 ± 0.07a	3.53 ± 0.50a
	2004	7.4 ± 1.7a	0.67 ± 0.11b	5.00 ± 0.81b
	2005	7.5 ± 1.7a	0.51 ± 0.11a	3.83 ± 0.80a
	Mean	7.5 ± 1.9B	0.54 ± 0.13D	4.07 ± 0.95D
'Spartan'	2002	7.8 ± 1.6b	0.41 ± 0.03a	3.21 ± 0.20a
	2003	6.4 ± 2.2a	0.46 ± 0.04ab	2.87 ± 0.26a
	2004	7.1 ± 1.4ab	0.48 ± 0.07b	3.39 ± 0.52b
	2005	6.8 ± 2.2ab	0.45 ± 0.05ab	3.06 ± 0.31a
	Mean	7.0 ± 2.0AB	0.45 ± 0.05C	3.13 ± 0.40C

Means ± standard deviation (SD); same lower-case letters indicate no significant difference between years; same capital letters indicate no significant difference between varieties ( $\alpha = 0.05$ ; Tukey's HSD test).

in 2005). Irrespective of the variety, the highest nectar mass was recorded in 2005, when precipitation exceeded the long-term norm by 60%. Nectar production depends strongly on a range of abiotic factors such as precipitation, air temperature, air humidity, light availability, and CO<sub>2</sub> concentration, and significant interannual variation in nectar and sugar quantity were reported by numerous studies (Denisow et al., 2014; Enkegaard et al., 2016; Jachula et al., 2019; Jachula, Konarska, & Denisow, 2018). Nectar characteristics also differed between varieties, e.g., nectar mass per flower was more than twofold higher in 'Bluecrop' than in 'Darrow'. Differences in nectar production between varieties is a known phenomenon which suggests the importance of genetic factors regarding nectar secretion (Bertazzini & Forlani, 2016; Bożek & Wieniarska, 2006; Masierowska & Piętka, 2014).

The studied *V. corymbosum* varieties produced considerable numbers of flowers, which, together with high per-flower sugar mass, resulted in high sugar yield per shrub, ranging from 9.4 to 20.7 g ('Bluecrop' and 'Darrow', respectively). Thus, approximately 47.0–103.5 kg nectar sugars can be expected from 1 ha highbush blueberry crop. In the current study, the estimated sugar productivity of 'Bluecrop' and 'Darrow' was two- to threefold higher than that estimated by Jabłoński

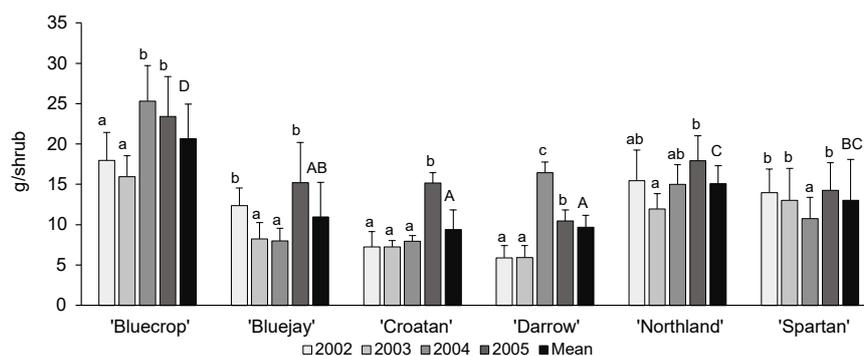
**Table 3** Nectar mass, nectar sugar concentration, and nectar sugar mass (at the peak of nectar secretion) in six *Vaccinium corymbosum* varieties in 2002–2005, Niemce, SE Poland.

Variety	Year	Mass of nectar/1 flower (mg) (mean ± SD)	Sugar concentration (%) (mean ± SD)	Mass of nectar sugars/1 flower (mg) (mean ± SD)
'Bluecrop'	2002	10.42 ± 2.62a	53.5 ± 7.7b	5.47 ± 1.12a
	2003	19.66 ± 3.96b	30.6 ± 9.6a	5.71 ± 0.97a
	2004	19.45 ± 1.93b	33.8 ± 4.2a	6.62 ± 1.25ab
	2005	26.77 ± 6.34c	29.7 ± 5.3a	7.78 ± 1.51b
	Mean	19.08 ± 7.09B	36.9 ± 12.0A	6.39 ± 1.52B
'Bluejay'	2002	8.78 ± 1.07a	47.6 ± 9.2b	4.19 ± 1.03ab
	2003	7.91 ± 1.95a	39.8 ± 8.6a	3.15 ± 0.99a
	2004	6.92 ± 1.07a	50.1 ± 8.7b	3.42 ± 0.62a
	2005	12.84 ± 3.99b	41.7 ± 8.9a	5.34 ± 2.03b
	Mean	9.11 ± 3.25A	44.8 ± 9.8B	4.02 ± 1.54A
'Croatan'	2002	11.55 ± 2.39b	36.3 ± 6.4a	4.08 ± 0.65ab
	2003	11.04 ± 1.65b	41.5 ± 5.5ab	4.53 ± 0.59b
	2004	7.56 ± 1.34a	44.8 ± 5.3b	3.34 ± 0.39a
	2005	12.72 ± 2.29b	43.3 ± 10.4ab	5.37 ± 1.08c
	Mean	10.72 ± 2.75A	41.5 ± 7.9AB	4.33 ± 1.03A
'Darrow'	2002	8.41 ± 2.38a	53.7 ± 10.5b	4.41 ± 1.4a
	2003	16.73 ± 4.34b	34.3 ± 4.5a	5.69 ± 1.48ab
	2004	15.47 ± 2.91b	45.2 ± 8.7b	6.80 ± 0.84b
	2005	25.78 ± 9.53c	26.8 ± 9.8a	6.14 ± 1.1b
	Mean	16.60 ± 8.31B	40.0 ± 13.4AB	5.76 ± 1.51B
'Northland'	2002	10.96 ± 4.03b	40.6 ± 14.6a	3.92 ± 0.63b
	2003	7.91 ± 1.82a	44.3 ± 7.5a	3.39 ± 0.51ab
	2004	5.83 ± 1.2a	51.8 ± 7.6b	3.00 ± 0.65a
	2005	11.73 ± 2.71b	41.6 ± 9.2a	4.68 ± 0.73c
	Mean	9.11 ± 3.57A	44.6 ± 11.0B	3.75 ± 0.89A
'Spartan'	2002	8.14 ± 1.67a	53.6 ± 5.9b	4.36 ± 0.98ab
	2003	11.58 ± 2.62b	40.2 ± 10.1a	4.54 ± 1.19b
	2004	6.41 ± 1.13a	49.1 ± 7.4b	3.17 ± 0.81a
	2005	12.25 ± 2.58b	39.0 ± 12.6a	4.66 ± 1.49b
	Mean	9.59 ± 3.19A	45.5 ± 11.2B	4.18 ± 1.29A

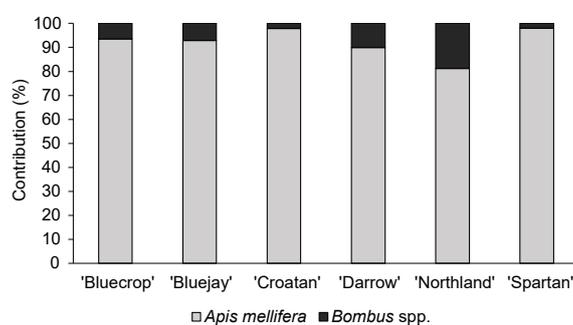
Means ± standard deviation (SD); same lower-case letters indicate no significant difference between years; same capital letters indicate no significant difference between varieties ( $\alpha = 0.05$ ; Tukey's HSD test).

et al. (1983); however, this previous study assessed sugar mass in young (3–4 years old) shrubs, and the authors emphasized that a considerably higher yield can be expected in older shrubs. High sugar productivity by highbush blueberry places this species among the best sugar-yielding cultivated shrubs in the Polish climate. For comparison, the estimated sugar yield of black currant is 4–7 kg/ha (Jabłoński et al., 1997), and that of raspberry is 39–41 kg/ha (Szklanowska et al., 1989).

In flowers of *V. corymbosum*, anthers open through pores at the tips (Courcelles et al., 2013), thus pollen can be released through sonication by insects, suggesting the so-called buzz-pollination syndrome (Hoffman et al., 2018). This trait can strongly affect pollinator efficiency (Courcelles et al., 2013), and more than 50 Apoidea genera are known to collect pollen released from anthers by sonication (e.g., *Bombus* spp., *Xylocopa* spp., and *Andrena* spp.); however, this does not occur in *Apis mellifera* (de Luca & Vallejo-Marín, 2013). Nonbuzzing insects can collect only small amounts of pollen from buzz-pollinated flowers, thus they are considered low-efficiency pollinators (dos Santos et al., 2009; Solís-Montero et al., 2015). According to my observations, honey bees were interested only in nectar. It was shown, however,



**Figure 3** Nectar sugar mass per shrub (mean  $\pm$  SD) in six *Vaccinium corymbosum* varieties in 2002–2005. Same lower-case letters indicate no significant difference between years, and same capital letters indicate no significant difference between varieties ( $\alpha = 0.05$ ; Tukey's HSD test).



**Figure 4** Proportional contribution of insect guilds visiting six *Vaccinium corymbosum* varieties in Niemce, SE Poland. Data of 2002–2005 are shown.

that even when not collecting pollen from corbiculae, *A. mellifera* can assume substantial amounts of pollen on its body while foraging for nectar (up to  $713 \pm 128$  pollen tetrads of *V. corymbosum*) and thereby contribute to pollination (Hoffman et al., 2018). This, in turn, may explain high the fruit set in highbush blueberry when flowers were visited mainly by honey bees (Bożek, 2009). Beside the specific anther structural characteristics, flowers of some *V. corymbosum* varieties show long, narrow corollas (e.g., 'Bluecrop') and seem to be adapted to pollination by insects with long mouthparts. According to Courcelles et al. (2013), over 40% of visits made by honey bees to 'Bluecrop' flowers were illegitimate, i.e., the bees sucked nectar by inserting their proboscis between the flower corolla and the inferior ovary (thereby avoiding touching the anthers); the authors also observed that *A. mellifera*, when foraging legitimately, inserted not only the proboscis but also pushed their head into the flower to reach nectar. I did not notice nectar robbing in any of the studied variety but frequently observed honey bees inserting their whole heads in the corolla.

In the USA, which is where highbush blueberry occurs naturally, the most frequent flower foragers were *Andrena* spp., *Bombus* spp., and *Xylocopa virginica* (MacKenzie & Eickwort, 1996; Scott et al., 2016). A previous study on nectar production and pollination in *V. corymbosum* in the Polish climate showed that flowers are visited mainly by honey bees and occasionally by bumble bees, *Andrena* spp., and *Megachile* spp. (Jabłoński et al., 1983). In the present study, only honey bees (>80% of insect visitors) and bumble bees were observed to forage on *V. corymbosum* flowers. The low abundance of bumble bees and lack of other wild pollinators of highbush blueberry may result from competition with honey bees. Increasing evidence suggests that high abundances of honey bees can reduce population sizes of wild pollinators (Geldmann & González-Varo, 2018; Jachula et al., 2020; Lindström et al., 2016; Thomson, 2016).

In conclusion, *V. corymbosum* is an important food crop in agricultural areas. This species flowers abundantly and produces large amounts of nectar sugars. Highbush blueberry can add to spring and late spring sugar resources, which is especially important for honey bees.

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