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RESEARCH ARTICLE

The study of seasonal activity of bumblebees (Hymenoptera: Apidae, *Bombus* Latreille) in the Middle Ob lowlands

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The features of the seasonal activity of bumblebees *(Bombus distinguendus, B. pascuorum, B. bohemicus, B. flavidus, B. sylvestris, B. hypnorum, B. jonellus, B. sporadicus, B. lucorum, B. sichelii)* of the Middle Ob lowlands are studied. The total abundance of bumblebees during the flight period depends on the sum of effective temperatures in the spring months (the correlation coefficient is 0,99 (p=0,05)). The total abundance of bumblebees is less dependent on the sum of effective temperatures in the spring-summer-autumn months (the correlation coefficient is 0,50 (p=0,05)).
Key words: *Bombus*, seasonal activity, bumblebees, the sum effective temperatures, Middle Ob

Seasonal changes in the bumblebees behavior depend on their geographical habitat. The annual temperature conditions vary in different geographical regions. If in the middle latitudes of the Western and Eastern hemispheres, the activity of bumblebees lasts 4–5 months, then in the northern latitudes of these hemispheres the period of activity is no more than 3 months. (Efremova, 1991).

The seasonal activity of insects is closely interrelated with phenological features. The flight of bumblebees after the winter diapause can be phenologically related to the flowering of early spring plants (willow, coltsfoot, etc.). An increase in the number of bumblebees by mid-summer is connected with the mass appearance of working bumblebees and with the growing attractiveness of flowering plants in this period. The maximum number usually coincides with the maximum flowering and nectar productivity of clover.

The aim of our study was to reveal the features of bumblebees seasonal activity in the conditions of the Middle Ob lowland and its dependence on the sum of effective temperatures during different flight periods.

Materials and methods

The seasonal activity dynamics of bumblebees has been studied by the authors three years (2008–2010) from April to October on a dry grass meadow in the vicinity of the village Saygatina, located in the Surgut portion of the river Ob floodplain. The studies were conducted every ten days (at least 1 collection for 1 decade) according to the standard method (individual catching on an area of 500 m2 within 30 minutes during the most active flight of bumblebees). To study the dependence of the bumblebees number in the flight period on the sum of effective temperatures we performed the correlation analysis (Pearson correlation coefficient) and regression analysis (coefficient of determination, denoted R^2).

Phenological observations of bumblebees were carried out according to the standard methods (Tudanov, Roshchinenko, 2007) and included the registration of the flyout times of overwintered females, time for laying nests, the appearance of working bumblebees, males and young females. The time of the nests laying was recorded by the appearance of females with pollen loads in the communities, because without a nest the bumblebee does not collect pollen for storage.

Results and Discussion

Currently, in the Middle Ob lowlands, there are 26 registered species of bumblebees of the genus *Bombus* Latr. (Demidova, Tyumaseva, 2008, 2011; Demidova et al., 2018). The phenological observations have shown that the beginning of flyout from wintering differ in different species of bumblebees (Table 1). Different dates of the adults flyout are explained by their physiology, associated with a certain amount of heat necessary for bumblebees to come out of winter stupor. Thus the flyout of insects mainly depends on the temperature of the environment.

Table1. The duration of bumblebees flight periods in the Middle Ob lowland (2008–2010)

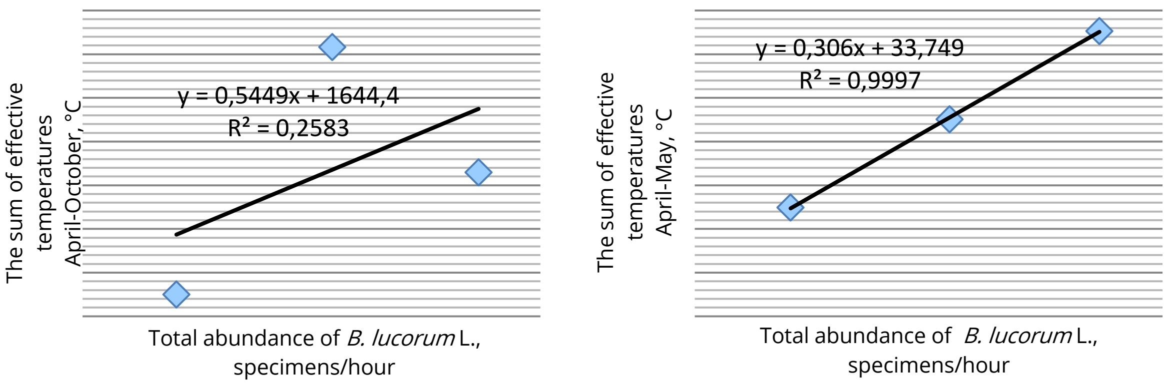
2008 – 2010 Species of bumblebees	April	May			June			July			August			September			October
	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I
B.distinguendus																	
B. pascuorum																	
B. bohemicus																	
B. flavidus																	
B. sylvestris																	
B. hypnorum																	
B. jonellus																	
B. sporadicus																	
B. lucorum																	
B. sichelii																	

The timing of the females spring flyouts from wintering grounds also depends on the habitat. In open areas, snow comes off earlier than in the forests, the earth warms faster, and bumblebees fly out earlier. It also matters in which soils bumblebees hibernate: heavy loamy soils are warmed worse than the sandy ones (Efremova, 1991).
The date of adult bumblebees flyout varies over the years, as evidenced by our research. The average temperature in the period from April 10 to October 20 (2008–2010) is provided in Table 2.

Table 2. The average temperature in 2008–2010 in the vicinity of Surgut

	April			May				June				July				August				September				October		
	II	III		I	II	III		I	II	III		I	II	III		I	II	III		I	II	III		I	II	
2008	-9,4	0,0	**-4,7**	2,9	9,3	6,6	**6,3**	8,5	13,5	14,8	**12,3**	15,8	20,5	19,4	**18,6**	14,7	12,4	13,4	**13,5**	11,1	5,8	4,9	**7,3**	6,4	-3,2	**1,6**
2009	-1,6	3,2	**0,8**	2,5	4,9	6,1	**4,5**	14,8	12,9	10,7	**12,8**	16,9	19,9	15,9	**17,6**	15,0	16,6	16,6	**16,1**	13,9	9,0	8,9	**10,6**	7,7	0,7	**4,2**
2010	0,3	5,7	**3,0**	2,6	0,1	4,7	**2,5**	12,7	13,3	14,6	**13,5**	13,9	16,3	17,7	**16,0**	17,3	12,3	11,9	**13,8**	8,1	4,7	5,4	**6,1**	4,0	3,6	**3,8**

In 2008 and 2009, the flyout occurred in the first decade of May (May 7 and 8, respectively) at temperatures of 11–14°C, single bumblebees were recorded in April (at temperatures above 10°C). In 2010, bumblebees were first registered on April 24, at a temperature of 13°C, until the end of May they were met sporadically, and only in early June the meetings became permanent.
The females of *Bombus lucorum* were the first to fly out after the winter diapause. The flyout was in the third decade of April – the first decade of May, depending on the year. The stable occurrence was usually observed in May. After them in early May, *Bombus pascuorum* and later bumblebees of other species flew out.
The longest flight period was observed in *Bombus lucorum, Bombus pascuorum*, *Bombus sporadicus*.
The seasonal activity of bumblebees lasts 157–170 days.
The dependence of the total abundance of bumblebees on the sum of effective temperatures in different flight periods is shown on the graph (Fig. 1 a, b). The temperature threshold accepted for the third decade of April – the first decade of May is 10°C, from the second decade of May to the first decade of October – 0°C.



a b

Figure 1. Dependence of the total abundance of bumblebees on the sum of effective temperatures in different flight periods (2008-2010): a. April-October; b. April-May.
Note: R^2 is a determinant coefficient (a measure of regression model quality describing the relationship between dependent and independent model variables).

According to literature data, it is noted that the beginning of the spring bumblebees flight occurs at average daily temperatures not lower than 10 degrees (Efremova, 1991). Bumblebees are able to maintain the body temperature of 20–30 degrees higher than the ambient air temperature, and flights are marked even at 0°C (Panfilov et al., 1960).

We found that the number of bumblebees during the flight period depends on the sum of effective temperatures in the spring months – the time when the bumblebees fly out after the winter diapause. The correlation coefficient (an indicator of the mutual stochastic effect of a change in two random variables) of the number of bumblebees and the sum of effective temperatures (April–May) is 0,99 (p=0,05). The total abundance of bumblebees is less dependent on the sum of effective temperatures in the spring-summer-autumn months. The correlation coefficient of the bumblebees abundance and the sum of effective temperatures in the period from April to October is moderate, equal to 0,50 (p=0,05). Basing on the determination coefficient indicators ($R^2_{April–October}$=0,258; $R^2_{April–May}$=0,999 – Fig. 1) in the regression equation, when comparing the sum of effective temperatures for April-May and the total abundance of bumblebees during their flight periods in different years, we have 99,9% of the effective character dispersion, and other factors account for 0,1% of its dispersion (т.е. residual dispersion). When comparing the sum of effective temperatures for April-October and the total abundance of bumblebees, we have 25,8% of the effective character dispersion, and other factors account for 74,2% of its dispersion. In the latter case, one of the obvious factors can be marked by sharp temperature fluctuations in the spring months. We have traced the following pattern: with a relatively uniform temperature increase from spring to summer months, when the stable positive air temperature is established and has only slight fluctuations, the number of bumblebees is much higher than at sharp changes from positive to negative temperatures in spring, and vice versa.

The phenological processes and seasonal activity dynamics have been studied in detail for the mass species *Bombus lucorum* (Fig. 2).

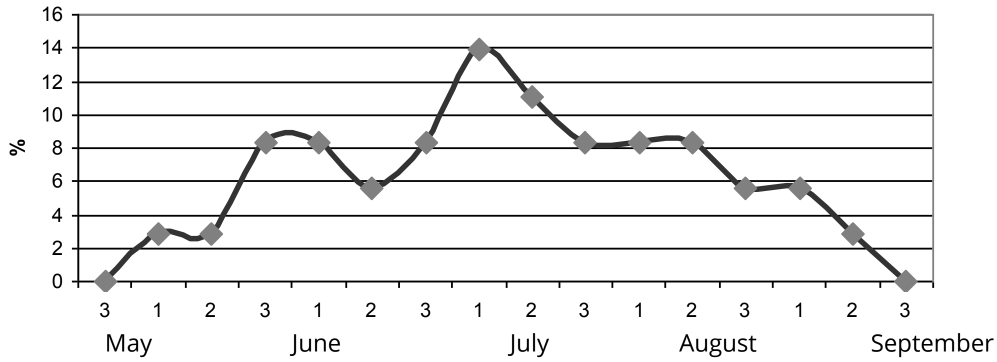


Figure 2. Seasonal activity of *Bombus lucorum* L. in the Middle Ob lowlands (average data of 2008–2010).

The laying of the *Bombus lucorum* nest presumably fell on the second and third decade of May, it was at this time that females appeared with pollen loads. The first working individuals were recorded in the third decade of May – the first decade of June. Their mass foraging was in the third decade of June – the first decade of July. Young females and males appeared in August. By the end of September, there was a decline in the abundance of bumblebees.

Conclusions

The seasonal activity of bumblebees lasts 157–170 days. The maximum number of bumblebees is observed in the third decade of May. The latest bumblebees are found in the third decade of September, and the flight of *Bombus lucorum* lasts till the first decade of October. The phenological processes delay, compared with the southern areas, is two weeks. The total abundance of bumblebees during the flight period depends on the sum of effective temperatures in the spring months (the correlation coefficient is 0,99 (p=0,05)). The total abundance of bumblebees is less dependent on the sum of effective temperatures in the spring-summer-autumn months (the correlation coefficient is 0,50 (p=0,05)).

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