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Biology of the Spotted-Wing *Drosophila suzukii* (Diptera: Drosophilidae) in Hokkaido, Northern Japan. III. Breeding on Blueberries

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北海道におけるオウトウショウジョウバエの生態. III. ブルーベリーでの繁殖

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ABSTRACT

Breeding of *Drosophila* (*Sophophora*) *suzukii* on blueberries was studied during the entire ripening season from July to October in Hokkaido, northern Japan. The species began to use blueberries from late July in the years 2016, 2017, and 2018 and from early August in 2019; about 95% of the fruits were infected by *D. suzukii* females from late August to late September. The active breeding of *D. suzukii* on blueberries peaked in late August, and number of adults that emerged from a single blueberry fruit was 4.2 ± 2.1 ($n=20$), with the maximum number being 9. For breeding of *D. suzukii* on cherry fruits, the damage ratio was quite low, because of its fruiting period being about 1 month earlier than the appearance of *D. suzukii* in Hokkaido.

Keywords: infection, emergence, damage ratio

1. INTRODUCTION

We extensively surveyed the breeding and feeding substrates of the spotted-wing *Drosophila suzukii* in Hokkaido, northern Japan, in a previous study, and reported that this species possesses a broad host range, that includes various wild and cultivated fruits (Kanda et al., 2019a). *Drosophila suzukii* oviposits mainly on fresh fruits on trees, and is a major pest of blueberries (*Vaccinium* spp.). The fruit season usually starts from late July around Sapporo, and continues until early October. We studied seasonal

changes in the percentage of the blueberry fruits damaged by *D. suzukii* and the number of adults emerging from a single fruit during the ripening season. The fecundity of the *D. suzukii* female was also studied under laboratory conditions to estimate its clutch size—the number of eggs laid by a single female per visit to a fruit of blueberry in the nature.

2. BREEDING AND FECUNDITY

Field survey: Twenty ripe blueberry fruits were collected from trees in the fields of Sapporo; their weights were measured, and they were kept separately in plastic vials (30 mm in diameter, 100 mm in height), with moistened tissue papers on the bottom. All the fruits were free from insecticides. The vials were maintained in incubators at 18 ± 1 °C, and the adult flies that eclosed from the fruits were collected every day and identified. In addition, the damage ratios were determined for cherry (*Cerasus avium*) and tomato (*Solanum lycopersicum*) fruits infested by *D. suzukii* during the fruit season.

Fecundity: The egg production by female *D. suzukii* was determined at 18 °C, as follows: a pair of newly emerged male and female was placed together in a glass vial (22 mm in diameter, 100 mm in height) containing the usual *Drosophila* medium on a plastic plate (Watabe et al., 1991). The number of eggs laid by a single female of *D. suzukii* was counted every day for 1 month, with regular renewal of food.

3. RESULTS AND DISCUSSION

The seasonal changes in the percentage of blueberries from which *D. suzukii* eclosed, during the period from late July to early October, 2019 are shown in Figure 1. In the Kanto district of Honshu, *D. suzukii* adults begin to emerge from blueberries from late June, and in Hokkaido they appear from late July or early August. In Hokkaido, *D. suzukii* appeared about 1 month later than in Honshu. In mid-August, *D. suzukii* adults emerged from almost half of the blueberry fruits. Thereafter, the damage ratio of blueberries by *D. suzukii* rapidly increased and peaked in late August. More than 90% of the blueberries were infested with *D. suzukii*. Serious infestation of blueberries by *D. suzukii*, to varying degrees, has been reported in many countries. In North America, to which blueberries are probably

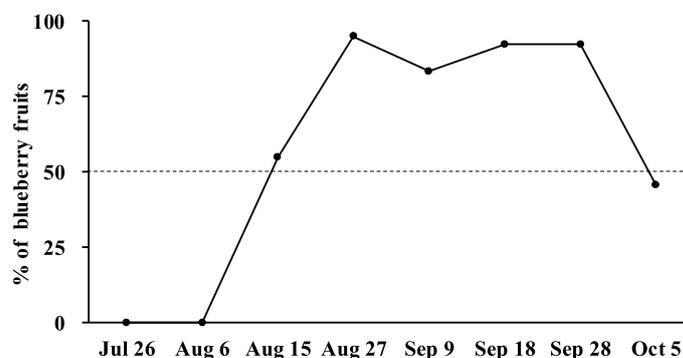


Figure 1. Seasonal changes in the percentages of blueberry fruits from which *Drosophila suzukii* adults eclosed during the period from late July to early October, 2019.

native, about 5% of blueberries were damaged by *D. suzukii* (Bolda et al., 2010). The damage ratio falls between 10% to 30% of the total crop in most cases (Utino, 2005; Kawase et al., 2008; Seto et al., 2015), and therefore, a high damage ratio found in the present study should be remarkable for the crop yields of blueberries in Hokkaido. In fact, we observed maggots (probably, all were of *D. suzukii*) in many blueberries on trees from late August to late September. The breeding of *D. suzukii* on blueberries became low from early October, when the daily mean temperatures decreased below 15 °C.

The time of start of *D. suzukii* breeding was somewhat different from year to year in Hokkaido. In 2016 when *D. suzukii* had built up a large natural population in August (Kanda et al., 2019b), the oviposition of *D. suzukii* females was observed from July: 16.7% of the blueberries ($n=24$) had been damaged by the species in late July and 51.4% ($n=222$) were damaged in early August.

The number of adult *D. suzukii* that emerged from a single blueberry in late August, 2019 is presented in Figure 2. The size of blueberries was variable, and their weight ranged from 0.60 to 1.50 g (the mean \pm SD was 1.07 ± 0.35). The adult flies eclosed in 19 out of 20 fruits, and the average number of eclosed flies was 4.2 adults per fruit. One of the fruits (#13 in Fig. 2) yielded the maximum number of nine adults, and three fruits (#3, 5, 7) yielded seven adults each. The ovaries of the new adults developed without any deficiency and these individuals performed the next breeding. It is well known that the number of adults emerging from a single fruit varies with the ripening stage, and with the blueberry variety and season. Lee et al. (2011) studied the number of *D. suzukii* adults that emerged from different races of blueberries and at different stages of ripeness of fruits in the United States, and reported that number of adults was usually about 1 to 10. Tsushima and Murai (2017) observed about 15 adults from a fruit of blueberry in late July in Aomori Prefecture in Tohoku district. This is the maximum number for the breeding of *D. suzukii* on blueberries.

Table 1 shows the number of eggs laid by a single female of *D. suzukii* at 18 °C. In the present study, the females began to deposit eggs, starting 1 week after eclosion. The state of oviposition of *D. suzukii* was quite unpredictable, probably owing to the artificial culture conditions. However, the data presented in the table clearly indicate that a single female could produce at most 9 eggs per day (for #4 female, on day 29 of eclosion; Table 1). The fecundity of *D. suzukii* on various fruits and artificial food has been

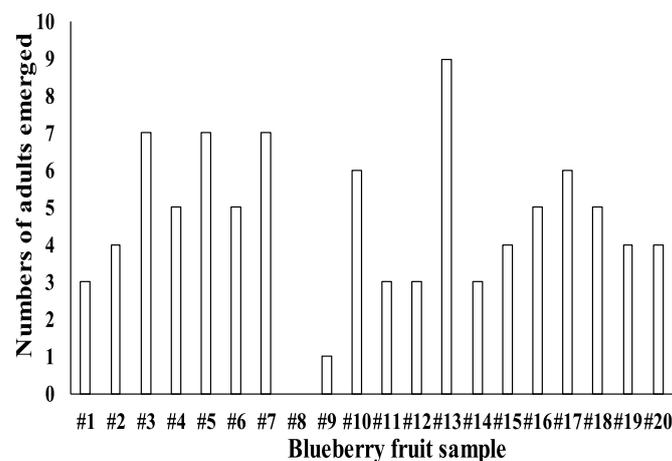


Figure 2. Numbers of *Drosophila suzukii* adults that emerged from 20 blueberry fruits collected from a garden on August 27, 2019.

Table 1. The number of eggs deposited by a single female of *Drosophila suzukii* during one month.

Day	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Total	
#1			1		1	2	3		3		1						1		1		1		1		15	
#2						1			2	2		1	1		6	1	1					1				16
#3							1					1		1	4							3		1		11
#4	2		1				1	1		2	1	1			6		4	2	1		3	2	9	4	40	
#5				2		3		6	3				2		1	1	6		1	3	7		2	1	38	
#6				5				1	5				1		6		3	1	6	1		*			29	
#7								1		2	1	1		1			1		*						7	

*dead

studied, and the oviposition rates may depend on rearing temperatures, age of the female, feeding substrates, among other factors. Kanzawa (1939) reported that the average number of eggs produced by a single female per day was 7–13, and Kinjo et al (2014) reported it to be more than 25 eggs per day. In our observations on breeding, the emergence of adults from a single fruit was recorded within a few days (mostly within a day), suggesting that the oviposition might have been done by a single female nearly at the same time (cf. Mitsui et al., 2006).

Cherry is well known as a favored host of *D. suzukii*. The earliest record of breeding of *D. suzukii* on cherries in Hokkaido was from July 5, 2016 (1 male from 98 cherries); thereafter, the number of individuals bred increased rapidly (19 males and 31 females from 34 fruits on July 20, 2016). Unlike in the Kanto and Tohoku districts of Honshu, where *D. suzukii* is a major pest of the cherry crop, the species does not seriously affect this crop in Hokkaido, at least until early July, because of its low population densities.

Drosophila suzukii often breeds on tomatoes and pears (Kanda et al., 2019a). We surveyed its breeding on damaged as well as non-damaged fruits with ridges on the surface, from August to October, and obtained new *D. suzukii* adults from three out of five damaged tomatoes, showing that the skin of tomatoes could not be penetrated by the serrated ovipositor of *D. suzukii*.

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