Pollination effect and activity of solitary bee, *Osmia cornifrons* on the middle-season and late-season cultivar

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ABSTRACT

In order to use *O. cornifrons* more effectively in apples, we investigated the pollination effect and nesting activity of the bee on "Hongro", the middle-season cultivar and "Fuji", late-season cultivar. The nesting activity, rate of trap nesting, and reproduction in “Fuji” were 2.5, 1.5, and 3.8 times greater than in “Hongro”. As a result of investigating the pollination effect according to the cultivars, “Fuji” was 1.6 times greater than that of “Hongro” in the central fruit set. In terms of the quality of fruit, Asymmetric index of ‘Fuji’ was 2.5 times lower than that of “Hongro”, and the number of apple seeds of “Fuji” was 1.9 times more than that of “Hongro”. In contrast, there were no significant differences in weight, shape index, and oblate index by cultivars. Because the temperature during the blooming period of apples affects the activity of the *O. cornifrons* (R^2=0.578), it is expected that the nesting activity and pollination effect are great in “Fuji” (17.4℃), when the temperature during the blooming period is higher than that of “Hongro” (12.5℃). Therefore, for stable fruit production of apples in “Hongro” cultivar, it is recommended to use a *Bombus terrestris*, which is less affected by the weather environment than *O. corinfrons*. However, it is considered that *O. cornifrons* can be used in the “Fuji” cultivar which was high temperatures and stable weather conditions.

MATERIALS & METHODS

- **Experimental insects and crops**
  - Hornfaced bee (*Osmia cornifrons*, 600bees: female 200bees, male 400bees)
  - Apple: the middle-season cultivar- "Hongro“, late-season cultivar "Fuji",
- **Pollination effect(Fruit set, quality), pollination activity, reproduction rate, . Correlation between nesting activity and air temperature**
- **Statistical analyses**
  - One-way ANOVA, followed by Tukey’s HSD as post-hoc analysis and T-test
  - Spearman’s correlation, the linear regression analysis
  - All statistical analyses were performed using SPSS PASW 22.0 (IBM, Chicago, IL, USA)

RESULTS

Table 1. Percentage of nesting activities of O. *cornifrons* females between different blooming seasons of apple cultivars in an apple orchard.

Cultivars	n	Average rate of nesting activities (%)		
		Incoming	Outgoing	Total [y]
Hongro	6	7.7±2.2[z]	4.9±0.6	12.6±2.5
Fuji	9	19.8±9.9*	11.2±5.5*	30.9±14.3*

[y] Total activity is the sum of incoming and outgoing
[z] mean±SD
“n” is the number of observations
* indicates that the data between cultivars were significantly different according to a t–test ($p < 0.05$).

Table 2. Rate of trap-nesting and reproduction of *O. cornifrons* between different blooming seasons of apple cultivars in an apple orchard.

Cultivar	n	Rate of trap-nesting (%)	Rate of reproduction (fold)
Hongro	12	11.0±1.3 [z]	0.4
Fuji	12	16.2±6.8*	1.5

* indicates that the rate of trap-nesting and reproduction between cultivars were significantly different according to a t–test ($p < 0.05$).

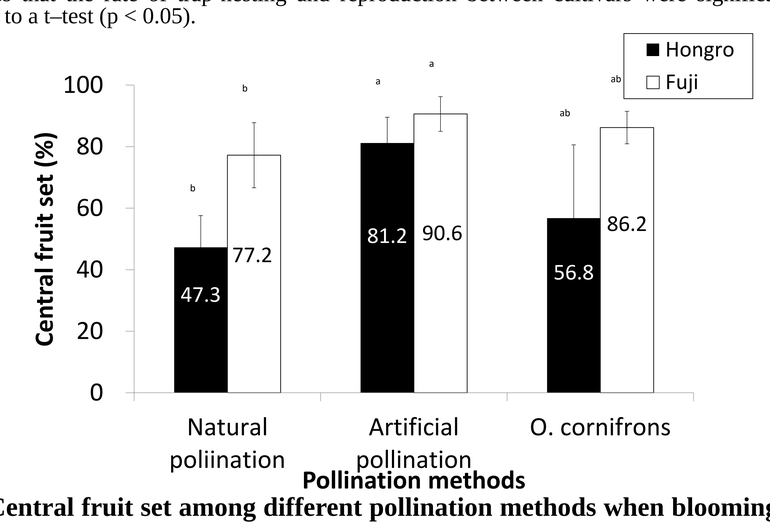

Fig. 1. Central fruit set among different pollination methods when blooming seasons of cv. Fuji and cv. Hongro in apple orchard.

Table 3. Fruit shape and L/D values of fruit for different pollination methods of cv. ‘Hongro’ and cv. ‘Fuji’ in the apple orchard.

Cultivars	pollination methods	n	L/D value[v]	Fruit shape (%)		
				Shape[w] index	Asymmetric[x] index	Oblate[y] index
Hongro	*O. cornifrons*	80	89.1±5.7 [z] a	66.3**	65.0* **	18.8
	Artificial pollination	20	87.9±4.9 a	65.0**	90.0*	15.0
	Natural pollination	40	83.9±6.6 b	30.0	95.0*	52.5
Fuji	*O. cornifrons*	80	88.2±5.7 a	55.0**	28.3**	20.0
	Artificial pollination	20	87.1±4.8 a	48.0**	28.0**	32.0
	Natural pollination	40	81.3±7.1 b	20.0	77.5	62.5

[v] L/D value= fruit length / fruit diameter
[w] The shape index is the percentage of fruits with L/D value above 0.87.
[x] The asymmetric index is the percentage of fruits with above 7 mm difference between minus the minimum fruit length and the maximum fruit length.
[y] The oblate index is the percentage of fruits with L/D value below 0.84.
[z] mean±SD
Different letters indicate significant differences among pollination methods based on the results of one-way ANOVA and Tukey’s HSD ($p < 0.05$)
* indicates that the fruit shape between cultivars were significantly different according to chi-square test, respectively ($p < 0.05$).
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Table 4. Weight and number of seeds for different pollination methods of cv. ‘Hongro’ and cv. ‘Fuji’ in the apple orchard.

Cultivars	pollination methods	n[z]	Weight	Number of seeds
Hongro	*O. cornifrons*	80	385.1±80.8 [z] b	3.7±3.1 [z]
	Artificial pollination	20	441.9±62.9a	3.5±3.7
	Natural pollination	40	326.9±95.0c	1.7±1.8
Fuji	*O. cornifrons*	80	337.5±48.8	7.0±2.5*
	Artificial pollination	20	335.9±48.8	5.7±1.6
	Natural pollination	40	325.4±40.4	6.6±3.2*

Different letters indicate significant differences among pollination methods based on the results of one-way ANOVA and Tukey’s HSD ($p < 0.05$)
* indicates that the weight and number of seeds between cultivars were significantly different according to chi-square test, respectively ($p < 0.05$).

Table 5. Daily mean climatic conditions during the apple blooming period in different apple cultivation area for 10 years (2011~2020)

District	Air temperature(℃)			Humidity (%)	Wind velocity (m/s)	Precipitation volume (mm)
	Mean	Maximum	Minimum			
Jangsu-gun (Hongro)	12.5±1.7	20.2±3.3	4.8±3.6	65.3±19.2	1.1±0.2	2.6±5.8
Danyang-gun (Fuji)	17.4±1.9*	24.1±3.6*	10.2±4.1*	62.1±17.1	1.4±0.5	0.4±0.9

The blooming period is from March 13 to April 30.
* indicates that the rate of trap-nesting and reproduction between cultivars were significantly different according to t-test, respectively ($p < 0.05$).

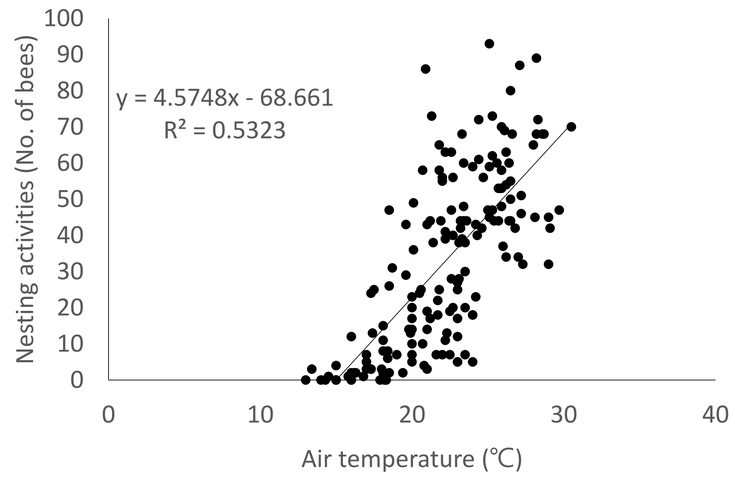

Fig. 2. Correlation between nesting activity and air temperature in this study.