Daily Activity of Wild Bee Pollinators on Strawberry in Highland Agriculture, Eastern Slope of Mount Slamet, Central Java

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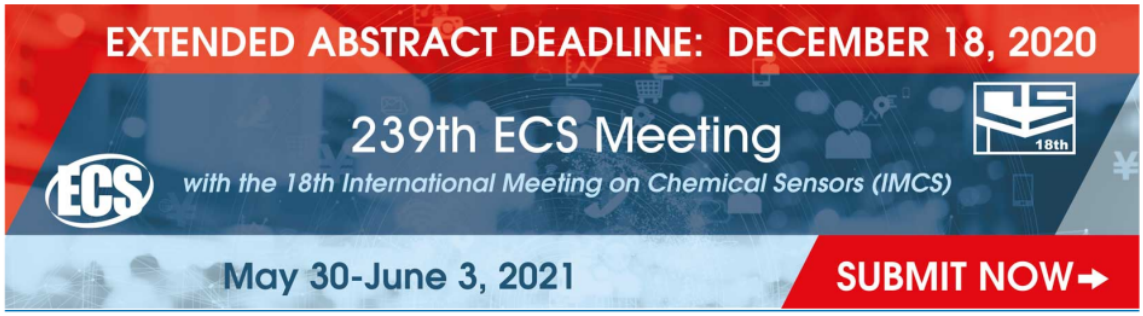

Daily Activity of Wild Bee Pollinators on Strawberry in Highland Agriculture, Eastern Slope of Mount Slamet, Central Java

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Abstract. Wild bees have a vital role in complementing social bee pollination in an agricultural landscape. Pollination effectiveness of wild bee depends on the daily activity of individual bees visiting flowers. This research aimed to understand the activity of wild bees visiting and pollinating flowers of strawberry. A survey has been done from April to July 2018 using scan sampling in 30 plants of strawberry. The results showed that strawberry flowers were visited by five bee species (*Nomia melanderi, Campsomeris fasciata, Ceratina dupla, Amegilla zonata,* and *Lasioglossum malachurum*). The daily activity of wild bee showed significant differences between species ($p<0,05$), but all species have the same pattern of pollination activity. The highest activity found between 9.00 and 12.00 pm and tended to decrease at the end of the day. The activity of wild bees to visiting flowers affected by daily temperature ($r = 0,86$). The conclusion was that wild bee species are highly competitive in food resources at midday. Some species showed ecological separation throughout the day. This research found that wild bee species have an important contribution to cash crop pollination in the agriculture area.

1. Introduction

Most bees depend entirely on dietary nectar and pollen for their sustenance, growth, and development. The sugars of ingested nectar are the primary source of energy for both adults and larvae of all bees. In addition, pollen provides all essential amino acids, some lipids (i.e., sterols), vitamins [1], and other chemicals central to bee health [2, 3]. How the pollen is incorporated into the diet of adults differs among bees, especially between eusocial and solitary species.

Diverse pollinator assemblages often share flowers of insect-pollinated plants as food sources [4], which might experience interspecific competition [5]. Frequent ecological separation suggests that pollinator competition is important and widespread, though little is known about direct consequences of the competition and resource partitioning on pollinator abundance and community structure [5, 6,7]. It remains poorly resolved whether the ecological separation of pollinators represents (1) incidental species differences that do not affect species interactions, (2) incidental species differences that facilitate competitor coexistence, or (3) species differences that evolved because they reduce interspecific competition [8].

Circumstantial evidence of such competition is the ecological separation of coexisting pollinators known to occur by space, season, food type, flower sex expression, flower color [9], flower shape, ambient temperature, and diurnal time. A diurnal time or daily activities play an essential role in the production and productivity of the crops, which is used to compare the pollination efficiency of

different wild bee species. More foraging frequency indicated more pollination efficiency [10]. The knowledge on bee daily activity and their interactions with different plant species are pre-requisite to frame on strategy for effective crop pollination. Similarly, initiation and cessation of foraging time help to determine the environmental effect on foraging behavior. Therefore, this study attempts to compare the daily activities of the wild bees in green beans and strawberry under natural conditions.

2. Methods

The research was conducted at Serang, Karangreja District Purbalingga, from April to July 2018. The plot size of strawberry was 3 m x 10 m (30 m^2) separated by 10 m distance between plots and 1m between replications. Each replication consisted of 30 individual crops.

Observation on the daily activity of wild bee included species of wild bee, number of flowers visited per minute, and number of bees in visiting flowers. These records were taken three times at 6.00-9.00, 9.00-12:00, and 13:00 -15.00 of the day at different green beans and strawberry flowering stages. Data were analyzed by Analysis of Varian using SPSS software.

3. Results

3.1 Wild bee diversity

Five species of wild bees have visited strawberry flowers during three-month observations, and these species were *Nomia* sp., *Campsomeris* sp., *Ceratina* sp., *Amegilla* sp. and *Lasioglossum* sp. Daily abundance was different amongst species with the highest was *Nomia* sp, and the lowest was Ceratina dupla (Table 1.)

Table 1. Abundance of wild bee species visiting strawberry flowers/day observation

Species	Number of individual /day
Nomia sp.	11,19 ± 4,60
Campsomeris fasciata	9,90 ± 9,31
Ceratina dupla	6,22 ± 4,23
Amegilla zonata	6,25 ± 2,91
Lasioglossum malachurum	8,56 ± 3,49

3.2 Daily activity

The daily activity of wild bees in visiting strawberry flowers showed the highest activity between 9.00 and 12.00, and tended to decrease in the afternoon. Only two species of wild bee, *Campsomeris fasciata* and *Lassioglosum malachurum* were active up to the sunset (Figure 2).

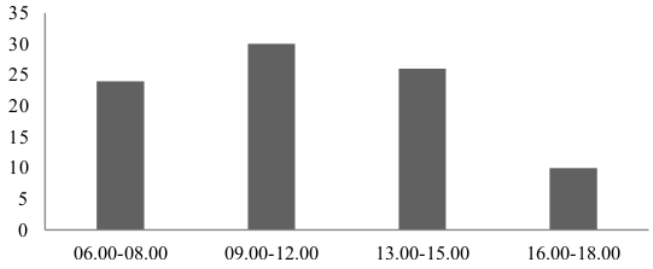

Figure 1. Daily activity of wild bee on strawberry flowers

Wild bee species showed significant difference activities ($p<0,01$) along the day, in which *C. fasciata* showed the highest activity. In contrast, the lowest was observed in *C. dupla* (Figure 3), and *L. malachurum* showed constant activity throughout the day.

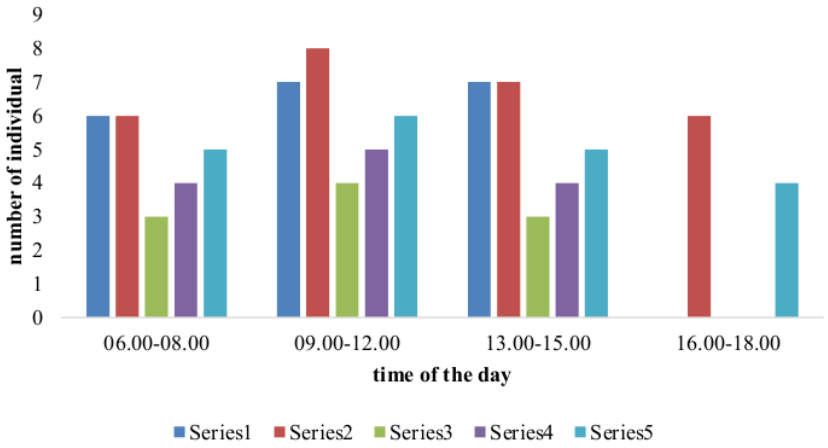

Figure 2. Daily activity of wild bees

Pollination activity based on the number of flowers visit, duration of visit, and the total number of flower visits is presented in figure 4. *Nomia melanderi* and *Ceratina dupla* were the bees with the highest and lowest flower visit, respectively. *L. malachurum* demonstrated the greatest constant visit throughout the day.

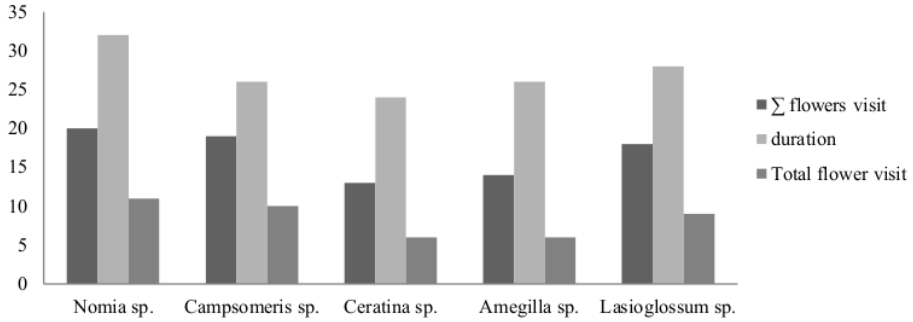

Figure 3. Flower visit activity

Analysis of variance demonstrated significant differences in solitary strawberry flower-visiting activity in five bee species. It implies that each of the bees possessed different characters for food searching. The food searching behavior and the body size of the bees were very diverse. Morphological characteristics of mouth shape and scopae to transfer pollen show their adaptation for collecting and bringing the pollen [10]. The analysis also showed the differences between the observation period ($p<0.1$) for a total visiting period amongst solitary bee species. Tukey test was carried out to investigate bee species possessing the highest total visiting period (error level 10%).

There was a test to examine further which species, *Nomia* sp. or *Campsomeris* sp., were more effective in assisting the pollination of Oso Grande strawberry cultivars. It was done because the

location surrounding the strawberry plantations containing litter and living grasses were suitable foraging place for *Nomia* sp. and *Campsomeris* sp., thus they might have also visited the closest strawberries plantation. The lowest of the bees visited, and pollinated strawberry plants were *Ceratina* sp. The solitary pollinating bee, *Ceratina* sp., demonstrated relatively less visit to strawberry plants. It is stated that although genus Ceratina (small carpenter bee) was a cosmopolite bee, it is less of a flower visitor; thus, its roles as a pollinator are considered less important [9].

4. Discussion

The discovery of five wild bee species in strawberry plantations has been consistent with [9]. The solitary bee species of *Nomia* sp., *Ceratina* sp., *Amegilla* sp., and *Lasioglossum* sp present in Village Serang, Karangreja. The native bees that mostly solitary were *Amegilla cingulata, Nomia melanderi, Ceratina* sp., *Lasioglossum malachurum, Lasioglossum leucozonium*, and *Xylocopa* sp. Their highest numbers were observed in artificial habitats such as agricultural areas, including strawberry plantations made and managed by farmers at the study site. The highest number of individuals was *Campsomeris* sp., which might be because its habitat was adjacent to the study sites of strawberry crop. This proximity allowed *Campsomeris* sp. to frequently visit and assist pollination in the strawberry plantation. Five solitary bees were observed to visit Oso Grande strawberry cultivar, and most of them were a member of family Apidae from order Hymenoptera. Wild bee of family Apidae has been reported to have the vigor of collecting pollen and nectar [9].

Most solitary bees were cosmopolitan and generalist, so the five species of solitary bees found at the study site also have similar characteristics. This allows the solitary bee to play an active role in visiting and assisting the pollination of strawberry plants. Agricultural land adjacent to the forest as a natural habitat of a solitary bee also allows them to find food more easily [4]. Strawberry plants that are widely expanded in Village Serang, Purbalingga, are one of the main destination plants for solitary bees to obtain pollen and nectar, besides other crops planted on agricultural land. Bee-assisted pollination usually has sticky and shiny pollens, thus allowing them to adhere to the pollinator body and transfer to the pistil stigma [11]. This study is in accordance with the strawberry flowers that have a small structure, brightly white with sticky pollen. Solitary bees such as *Nomia* sp. and *Amegilla* sp. also favored yellowish-white strawberry flowers [9]. Also, plants, having a white or yellow flower, in lowland forests of Kalimantan are pollinated by Genus Nomia [9]. Solitary bees such as *Amegilla* sp. visits white and orange flowers more frequently than other colors [12].

The activity of solitary visits observed from pollination of Oso Grande cultivar strawberry plants showed that *Nomia* sp. was a bee species with the highest value for all three parameters. Its body size is bigger (16 mm) compared to others, resulting in a long time in feed foraging. This result is consistent with finding that large body insects require much pollen. Therefore, the time to collect pollen is also longer [9]. *Ceratina* sp. is a solitary bee species with a most visit to flowers. This might occur due to its body size that relatively small (3-12 mm); hence, it requires not much pollen. As a result, its visiting time is relatively faster (12). The low activity of visit by *Ceratina* sp. on caisin flowers has also been reported. *Ceratina* sp. has a smaller body size, dan faster visiting time than bees with a large body [13].

5. Conclusion

Based on the results and discussion, it can be concluded that wild bees visitors were the consistent type for strawberry plantation, with variations in daily visits that differ amongst species. Wild bees play an essential role in assisting pollinate strawberries.

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