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Research Article

THE PREFERENCES OF BEE APIS CERANA ON FLOWER COLORS AND THE SOURCES OF SUGAR IN BENGKULU PROVINCE, INDONESIA

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ABSTRACT

The aim of the research was to examine the preferences of *Apis cerana* on flower colors (purple, white, yellow and red) and type of sugar (sugar sucrose, sugarcane juice and palm sap). The hypothesis of this research was that *A. cerana* chose different preferences on flower colors and sources of sugar. A total synthetic flowers used on this study were 120 flowers. The observations of bees visiting the flowers were conducted at The Laboratory of Animal Husbandry, Faculty of Agriculture, Bengkulu University in Bengkulu and in Kepahiang District, Bengkulu Province. Nectars provided three kinds of resources: of sugar sucrose, sugarcane juice and palm sap that were designed as factorial ANOVA of 4x3 with 10 replications for each treatment. The synthetic flowers being inserted by sugar sucrose, sugarcane juice and palm sap were served to be chosen by the *A. cerana* worker bees. The results suggested that there is no significant result of *A. cerana* visiting different colors of flower, but the purple flower color likely was visited more than white, yellow and red color, while palm sap was visited significantly the most than sugar or sugarcane. It meant that *A. cerana* in Bengkulu had no preference of flower colors but selectively choose on sources of nectar.

INTRODUCTION

Bee hive in Indonesia plays an important role, both in improving farmer income and strengthening the forest conservation (Saepudin, 2013a). Beekeeping can provide enough income for the farmer, while it doesn't require the cost of feed (zero cost feed), honey can be harvested every two months on flowering season or five times a year (Sihombing, 2005).

In term of the forest conservation, beekeeping likely is able to prevent forest illegal logging due to the important trees to develop and produce honey. The other reason is that bee pollination may increase plant seedling. Often considered as crucial species in ecosystems (Williams and Osborne 2009), *Apis cerana* pollinate a wide range of plants in both agricultural and natural habitats (Osgathorpe *et al*., 2012 and Saepudin, 2013).

The queen bee feed on royal jelly which is made from nectar and pollen that are collected by worker bees. Bee workers take the nectar and pollen and put them on the nest. By natural processing, the nectar change to be royal jelly and honey. For the development of the queen bee and their colonies, the bees require nectar and pollen for all year long (Saepudin, 2013).

Fulfilling the need of nectar and pollen, the worker bees feed many kind of available flower that have variety of color such as white, yellow, purple, red etc. In fact the influence of flower color on bee worker feeding behavior has investigated yet. So, the aim of this research was to observe whether the worker bees use flower color as preferences. However, the flowers are visited mainly by freely foraging *A cerana* between four colors of morphs; white, yellow, purple and red (Dyer *et al.* 2006).

It is a well-known fact that flower color is an important signal to pollinators and might influence pollinator behavior (Myczko *et al*., 2014).When pollinators discriminate among colors, this may influence patterns of pollen transfer, and thus gene flow and evolutionary dynamics, within and between species (Hopkins and Rausher 2012). It is often assumed that many flowering plants owe much of their floral polymorphism in color, shape and odor to the combined effects of attracting different pollinator species (Myczko *et al*., 2014). Many species of bees have been shown to discriminate on the basis of floral colors (Lunau *et al.* 1996). Colors appear to be

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particularly important for flower recognition (Myczko *et al*., 2014).

Honey bees learn colors quickly when they are rewarded according to colors choice (Ings *et al*. 2009). Recent work has also indicated that the strength of innate colors preferences can influence foraging performance in bees under natural conditions (Myczko *et al*., 2014). Intra specific pollinator discrimination may influence genotypic frequencies as well as the reproductive success 1of colors morphs in plants. There have been studies focusing on bumble bee preferences for colors morphs where morphs differ in nectar content, variability of nectar content or the effects of density on pollinator preferences for colors (Myczko *et al*., 2014).

Flowers producing nectar and pollen attract insect with a complex colors (Myczko *et al*., 2014). According to Olesen and Knudsen (1994), ultraviolet reflection from flower parts, nectar production, pollen traits and scent chemistry do not differ between the two morphs. Since more plant that grows in Indonesia has color white, yellow, Purple or red it is important to figure out which color was the most attractive to bees.

Although the colors morphs co-occur throughout the range of the species, their frequencies vary. For example the frequency of white among populations range between 5 and 40 %, and within individual populations, white is often aggregated (Olesen and Knudsen 1994).

Apis cerana behaves as grazers picking up nectar and pollen, biting a hole in the corolla and inserting the proboscis through the hole to collect nectar. Bee did not only suck flower nectar but also pollinated by hairy part of proboscis. It showed that there is mutual advantage relationship between plant and bee. Other insects select flowers based on its form and color, so plant performs inter-specific competition by producing colorful flowers to attract pollinators (Olesen and Knudsen 1994). Due to those information, the objective of the research was to examine flower colors choices (purple, white, yellow and red) in nature and verify the hypothesis that *A. cerana* differs in their choice of flower colors and the sources nectar (sugar sucrose, sugarcane juice and palm sap).

MATERIALS AND METHODS

Observations on *A. cerana* visiting to flower (artificial flower) were recorded three times a day at 7.00-8.00 AM, 12.00-13.00, and 16.30 – 17.30. The time of observation was designed based on bee feeding behavior that has been investigated (Saepudin, 2013). Bee that was taken to be observed was *A. cerana*, because it is classified as local bee, potential honey producer and relatively easy to be managed. The artificial flowers are imitations made of plastic and have the characteristics as their natural flowering plants. Common characteristics of flower include color, shape of flower, size and color of petal and Sepal. A total artificial flower observed were 120 flowers consisting of 30 flower for each color being placed at two different places namely The Laboratory of Animal Husbandry, Faculty of Agriculture, Universitas Bengkulu, Bengkulu that is located at lower area and in Kepahiang District near mountainous area. The both places were open areas that were surrounded with trees and shrubs. As bee feed were provided three kinds of resources: 20% sugar sucrose solution, 100% sugarcane juice and 100% palm sap that was designed as factorial design 4 x 3 with 10 replications at each treatment.

Sucrose sugar, sugar cane juice and palm sap were inserted into the middle of artificial flowers using a pipette and placed at 7:00 am every day. There are 10 replications in each combination of treatments

Statistical analysis

To analyze flower colors discrimination by *A. cerana* pollinators, every bee which visited the flower were noted. It means that the number of worker bees visiting artificial flower was considered as one datum. On the condition the same worker bee visited the flower was calculated as many as visitation. The more worker bees visiting flowers, the more attractive the flowers are.

The number of bees visiting each flowers was examined quantitatively by examined using one-way factorial ANOVA. The first factors were the color of flowers namely purple, white, yellow and red. Those are the most common color of flower in Bengkulu. The second factors were the sources of nectars namely sugar sucrose solution, sugarcane juice and palm sap. For each individual *A. cerana*, the number and percentage of its visits to each artificial flower were calculated. Since the result of ANOVA analyses was significant, it was followed by Duncan's Multiple Range Test (DMRT) to confirm whether the artificial flower colour as well as artificial bee feed source, namely sugar, cane and sap and the flower color were significantly responded differently by *A. cerana*.

RESULTS AND DISCUSSION

The result of this research was performed at Table 1, the average of *A. cerana* visits to the flower of white, yellow red and purple, were respectively 136, 141, 136 and 143 bees per day. Being tested with ANOVA there was no significantly different between bees visiting flower color (P> 0.05).

Table 1 The average of *A. cerana* visiting flower

Flower Color	Feed Sources			Average per day
	Sugar	Sugar cane	Palm sap	
	……tail……			
White	33	36	62	136
Yellow	44	41	56	141
Red	36	37	63	136
Purple	50	34	59	143
Average per day	168	148	240	556

So, *A. cerana* did not choose flower color as the sources of nectar and pollen. It was contradicted with Chittka (2001) conclusion that bees had very different senses, depending on the ultra violet (UV) of the flower. Other study conducted by Myczko *et al*. (2014) concluded that different color preferences within similar groups of bee suggest the necessity of providing different flower colors which can contribute to conservation of local fauna. The result of that there is no influence of a visit to the flower color has something to do environmental variation is relatively small because one of the factors which have great impact on the behavior of bees is environmental variation. It is reported Myczko *et al*. (2014) found in subtropical areas within

very different color preferences similar bumblebee groups suggest the necessity of providing different flower colors can roommates Contribute to conservation of local fauna. Other reason that the result was different was based on The Floral Reflectance Database (FReD) was created by researchers at Imperial College London and Queen Mary, University of London said that the petals appear two-toned to bees, the concentric colors drawing them towards the nectar. Bees have different colors detection systems from humans, and can see in the UV spectrum.

Other result, A. *cerana* preferred palm sap to sugar and sugarcane as an artificial sugar for bee feed. The condition of palm sap contains more water than sugar and sugarcane. The other fact that the aroma and taste of palm sap was the most similar to nature nectar.

Honey bees forage on a wide variety of flower species in order to collect pollen and nectar for feed. Pollen is the primary protein source for bees, while nectar is the primary energy source for bees and provides them energy for worker tasks (foraging, taking care of young, cleaning out the hive) and queen reproduction. Nectar is produced by plants in order to attract specific pollinators (Saepudin, 2013b). It is important that pollinators are attracted to the flowers to ensure successful bee visitation to the flowers.

Worker bees of 556 individuals were recorded (Figure 2). Based on ANOVA analysis of bees visiting the flowers on Figure 1, there is no significant difference between the colors. Consequently, there is no strong evidence for preference of color in this species.

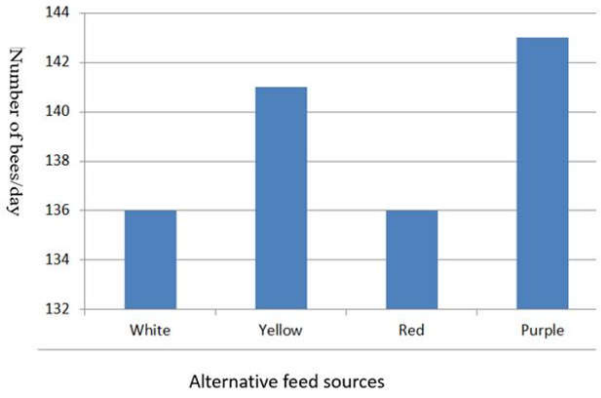

Figure 1 Number of *A. cerana* visiting each flower colors per day

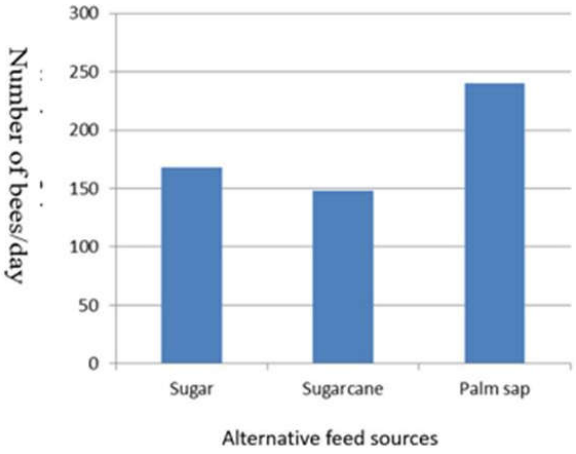

Figure 2 Number of A. cerana visiting each source of feed per day

A one-way ANOVA followed by Duncan's Multiple Range Test (DMRT) confirmed that the artificial bee feed source, namely sugar, cane and sap, significantly (P <5%) influenced bee visitation. Since the bees visit the flowers just to collect nectar and pollen, we assumed that higher number of bee visitors indicated feed resources highly favored by bees. This means that *A. cerana* do have a preference for alternative sources of feed. The average of bees visit flowers that contain sugar, sugarcane, palm sap were 168, 148 and 240 bees, respectively. *Apis cerana* in this study visit artificial flower with palm sap more than those with sugar or sugarcane. The statistical tests showed that bees feed resources significantly influenced their visit.

It was different from previous research that was conducted in subtropical area (Dyer *et al*., 2006, Ings *et al*. 2009 and Chittka *et al*., 2001) in Bengkulu which is located in tropical area, the petal color was not significant, which highlights the existence of different preferences in *A. cerana* with four flower color morphs. However, purple flowers have visited by the bee a little bit more frequently than than white, yellow and red. These preferences are similar to the study of Ings *et al*. (2009) who reported a preference of *B. terrestris* default color to purple flowers. However, the strength of these preferences differs between populations and colonies. Eckhart *et al*. (2006) showed, in a community of pollinators foraging on the color and shape of plant species polymorphic, frequency of visits correlated with particular morph frequencies in the population of an entire plant. Flowers sends a signal to attract the attention of potential pollinators and pollinator conform on certain traits, such as color, morphology, aroma and temperature flowers they visit to find feed (Dyer *et al*., 2006). Many species of plants are known to have a crown color variable association with traits of interest and other biological (Myczko *et al*., 2014). The properties can affect pollinators may special visit one type of color. McCall and Primack (1992) found that the flower color is important in determining the identity of a visitor. In another study, flowering penology (Herrera, 1988) or the amount of pollen or nectar reward offered greater effect on the visitor profile of properties of interest visible object. According to Olesen and Knudsen (1994), ultraviolet reflection from the flowers, nectar production and aroma chemicals did not differ between the two morphs of *C. cava*.

Unlike the bees that many papers show that they have an innate preference for "bee-purple" interest (Chittka *et al*., 2001 and Ings *et al*., 2009). In Chittka *et al*. (2001), seven species of bees from three subgenera tested: three from central Europe (*B. terrestris terrestris, B. lucorum,* and *B. pratorum lapidarius),* two from Asia (*Bombus ignitus* and *Bombus hypocrita*), and one of North America (*Bombus occidentalis*). All species showed a strong preference for shades of purple-violet range.

The different results between this study from previous studies due to many reasons. The possible reasons for the differences were that using different bees. In this study were used in this study were *A. cerana* that adapt to the heterogeneity of feed resources while the bees used in previous studies were the bees that were already adapting to the homogeneity of feed resources It is probable that competition for feed resources is intense during famine season most of the feed from flowers is limited at those times (Myczko *et al*., 2014). Patterns of feed-gathering Behavior in bumblebees were shown to be governed

by their relative tongue lengths, both directly when foraging for nectar (Yokoyama 2006) and indirectly when foraging for pollen (Myczko *et al*., 2014), so that tongue length governs overlap in feed use among bumblebee species.

It is possible that in this pollinator community, intra specific competition appears to be the primary mechanism involved in resource partitioning. This knowledge can be useful for *A. cerana* cultivation and enhancing pollinator diversity. Different colors preferences within one species suggest the necessity of providing different flower colors which can contribute to conservation of local fauna. We also believe that the results of our study should be taken into account when preparing agro-environment schemes designed to benefit pollinators.

The research that are being offered a glimpse of how bees may choice the color of flowers combined with the source of feed revealed any evidence. Those were 1. The ingressive behavior showed that *A. cerana* did not choose nectar based on flower color, 2. *A. cerana* is soundly not able to differentiate the flower color (color blind), 3. *A. cerana* prefers palm sap to sugar and sugarcane as an artificial sugar for bee feed.

CONCLUSION

The results suggested that there is no significant result of *Apis cerana* visiting different colors of flower, but the purple flower color was likely visited more than white, yellow and red color, while palm sap was visited significantly the most than sugar or sugarcane. It means that *A. cerana* in Bengkulu had no preference of flower colors.

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