

## DIVERSITY AND ABUNDANCE OF BEES (Hymenoptera: Apidae) IN THE CAMPUS 4 OF AHMAD DAHLAN UNIVERSITY

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Received: September 6, 2022. Accepted: November 18, 2022. Published: November 30, 2022

**Abstract:** Land conversion around campus 4 of Ahmad Dahlan University Yogyakarta affects the diversity and abundance of pollinating insects, one of which is bees. The purpose of this study was to calculate the level of diversity and abundance of bees on campus 4 UAD and its surroundings. The sampling area consisted of 4 plots, with each plot measuring 1750 m<sup>2</sup> (35 m x 50 m) determined using the observation method. Sampling was carried out three times, which was carried out in the morning at 07.00 – 11.00 and continued in the afternoon at 15.00 – 17.00. Bees were identified by comparing their morphological characters with identification reference books and journals. The Spearman correlation test then analyzed the bee abundance data and abiotic factors. The results showed that the level of bee diversity on campus 4 UAD and its surroundings was moderate (1 H' 3). The most abundant bee species was *Xylocopa aestuan*, with 118 individuals, and the least abundant was *Apis mellifera*, with 7 individuals. The conclusion of this study is the state of the ecosystem on campus 4 UAD and its surroundings, there is a disturbance in the form of land use change, but bees can still tolerate the disturbance.

**Keywords:** *Apis mellifera*, Bee, Campus 4 UAD, Land Conversion, *Xylocopa aestuans*

### INTRODUCTION

One of the insects that have various important roles in the ecosystem and is a key species is the bee (Hymenoptera: Apidae) [1]. Bees are insects from the Apidae family and consist of many species. The distance between agricultural land and natural habitat affects the species richness and abundance of insects, especially bees [2]. Shifting natural habitats into other functions, such as housing [3] or educational locations [4], can result in a decrease in species diversity and the abundance of bees in these ecosystems [5]. The land that used to be an empty land area with lots of flowering weeds has turned into campus buildings and densely populated areas such as housing and student boarding houses. The existence of this massive development can certainly reduce the area of green open areas with flowering weeds used by bees as food. Locations with ecosystems that change function due to massive development, one of which is campus 4 of Ahmad Dahlan University (UAD).

Ahmad Dahlan University is a private university in Yogyakarta with campuses spread across. One of the UAD campuses that is still under construction is campus 4. This development causes reduced open space and trees and can result in reduced species diversity and abundance of bees around the UAD campus 4 [6]. Research on the diversity of bees was conducted by Indraswari et al. on tomato plants in the Cisarua area, Bogor, West

Java, with the result that 11 species of bees were found [7].

In Rajasthan City, India, Kusuma and Doi [8] conducted a study on bee diversity, which took samples at two places, namely Government College and Herbal Park. It found that the Government College area contained the most dominant species from the Apidae family, namely *Apis dorsata*. Research on the diversity of insects around UAD campus 4 was conducted by Putra [9], regarding the diversity of ant species and other research, the diversity of butterfly species [10]. However, research on the diversity of bees itself has never been carried out around campus 4 UAD Yogyakarta. Thus, this research is important as an effort to determine the diversity and abundance of bees around campus 4 UAD Yogyakarta as a reference for campus development by paying attention to the ecosystems around campus 4 UAD Yogyakarta as well as being a database or as a reference for bee identification research around campus 4 UAD Yogyakarta.

### RESEARCH METHODS

#### Materials

The materials used in this study were bee samples obtained from the field, 70% alcohol to preserve the bees, and magic chalk to prevent insects from drying the bees.

## Methods

### 1. Determination of Sampling Location

The research locations were carried out in 4 areas, including the area around campus 4 of Ahmad Dahlan University, Yogyakarta (Figure 1). The four areas include the campus area, vacant

land, housing, and rice fields. The research method for determining the area uses observation [11]. Meanwhile, to determine the plot in sampling using a purposive [12]. Each sampling area is 1750 m<sup>2</sup> (35 m x 50 m).



Figure 1. Map of sampling plot [13]

### 2. Bees collection

Sampling was carried out at 07.00 - 11.00 and continued in the afternoon at 15.00 - 17.00. The choice of time for sampling is based on the active time of the bees [14,15,16]. Bees are caught using a sweep net. Sweep nets were swung back and forth within each plot in the study area to catch flying bees. The bees that have been caught are then put into a bottle filled with 70% alcohol. The bees that were caught were then brought to the Ecology and Systematics Research Laboratory at Ahmad Dahlan University for further identification. Sample identification was carried out by comparing the morphological characteristics of the bees obtained with the book from Mason et al. [17] and the journal of Francoy et al. [18]; Rattanawanee et al. [19]; and Al-Ghamdi et al. [20]

### 3. Data analysis

The data analysis used in this study was descriptive analysis to describe the bees found. The second analysis used in this research is inferential analysis. Inferential analysis was used to calculate the diversity level of bees using the Shannon-Wiener diversity index. In addition to calculating the diversity value, bee dominance was also calculated using the Simpson dominance index. The formula of the Shannon-Wiener Diversity Index ( $H'$ ), according to Sarma and Das [21], is as follows:

Note:

$H'$  = Shannon-Weiner diversity index

$n_i$  = The number of individuals of each species

$N$  = number of individuals of all species

The Shannon-Weiner Species Diversity Index criteria according to Prechzsch [22] were divided into 3, namely:

$H' < 1$ : Low diversity

$1 \leq H' \leq 3$ : Moderate diversity

$H' > 3$ : High diversity

Simpson's Dominance Index ( $D$ ), according to Thukral *et al.* [23], was calculated by the following formula:

$$D = \sum (n_i/N)^2$$

Note:

$D$  = Simpson dominance index

$n_i$  = The number of individuals of each species

$N$  = number of individuals of all species

According to Odum [24], the range of dominance index values is as follows:

$0.00 < C < 0.50$ : Low dominance

$0.50 < C < 0.75$ : Moderate dominance

$0.75 < C < 1.00$ : High dominance

## RESULT AND DISCUSSION

**The diversity level ( $H'$ ) and dominance of bees in the campus 4 UAD area, rice fields, vacant land and housing, Banguntapan District, DI Yogyakarta**

Based on the research results, the highest diversity index ( $H'$ ) is found in vacant land areas with a value of 1.52, and the lowest in paddy fields

with a value of 1.05. The highest dominance value is in the residential area, namely 0.53, and the lowest is in the vacant land area, with a value of 0.28 (Table 1).

Table 1. Diversity (H') and dominance (D) index values of bee species at campus 4 UAD, rice fields, vacant land, and housing, Banguntapan District, DI Yogyakarta

Location	H'	D
Campus 4 UAD	1.24	0.42
Rice field	1.05	0.50
Vacant land	1.52	0.28
Housing	1.18	0.53

If we look at the diversity index values at the four sampling locations, the four study areas have moderate diversity index values ( $1 \leq H' \leq 3$ ). However, of the four areas, vacant land has the highest H' value compared to other areas. This is because this study's vacant land is abandoned near urban areas. Vacant land near urban areas is usually overgrown with flowers and wild plants. According to Gardiner *et al.* [25], bees are more commonly found in vacant lands close to cities because these vacant lands can be used as habitats or nesting sites. The vacant land where this research was conducted has many flowering plants and is also far from human activity, so bees are abundant in the area. It is to the statement from Buadu *et al.*[26]; Papanikolau *et al.*[27]; and Addi and Bareke[28] that bees will be more commonly encountered if there are many flowering plants and away from human activity. According to Strane and Trippdi[29], human-caused land changes, especially the conversion of land to agriculture and settlements, have made some bees difficult to find. In addition, land clearing also results in the loss of some of the biodiversity found in the area[30]. The transition of land from vacant land to rice fields or settlements will certainly reduce the number of types of flowering plants that bees can use as a food source. The fewer types of food bees can get, the fewer bees can be found in that area. However, if the land still contains flowering plants, whether they are flowering wild weeds or cultivated plants, then bees can still be found in that area. The number of species found will be different from the land where there is still no disturbance in the form of land conversion from humans.

Regardless of this statement, the campus area, which is dense with human activity, can still be found with abundant numbers of bees. Even though human activity is denser in the campus area, bees can still survive if there are many flowering plants, which are a source of bee food [31]. The campus and housing areas have diversity index values that are not much different from the other

two, namely 1.24 and 1.18. The H' value obtained is due to land conversion, originally natural land into a campus and housing area[32], which impacts bee habitat. The statement from Otto *et al.* confirms this [33], and Schroeder *et al.* [34], that changes in bee habitat caused by land conversion will affect the availability of habitat used by bees to survive.

In general, a bee habitat that has been disturbed will result in few bees being found in the area [35], even to the point where bees are not found in the area [36]. However, in the campus and housing areas, almost all types of bees were found in these two areas. It can happen because bees can survive in areas that have changed land use[37], provided that there are flowering plants around the area as a food source and habitat for bees. Habitat for bees in areas affected by land use change will have a major impact on bees, but it can be overcome if the habitat has flowering plant resources. The availability of abundant flowers as a source of bee food can cause bees to visit more often and be found at that location[38].

Campus and housing areas have denser human activity than paddy fields [39]. Still, from the research results, the diversity index values in these two areas are higher than in the paddy fields. The factors causing the diversity index values in the campus and housing areas to be higher than the rice fields could occur. The flowering plants found in the two areas were more diverse and numerous than in the rice fields, so individuals and types of bees were found in the two areas more the. According to Hodgson *et al.*[40], bees can survive in dense human activities as long as there are flowering plants.

Another factor that causes the H value in campus and housing areas to be higher than in paddy fields is that the flowers visited are more attractive to bees to suck nectar from these flowers. Interestingly the flowers visited by bees are from the color of the flowers, shape, smell, and also the availability of pollen in these flowers[41]. The campus and residential areas have cherry, embarrassed daughter, Israel grass, euphorbia, and Bougainville. Cherry flowers have a small shape and are white, which is a source of food for the genera Apis and Xylocopa[42]. The shy princess flower has a lot of pollen available to attract bees[43]. Flowers, Israel grass, euphorbia, and Bougainville have an attraction in the form of striking flower colors that are purple, white, and red so that they can attract bees to visit these flowers[44]. The paddy fields only have rice flowers, chilies, and kersen. The three flowers have a small shape and are white, in contrast to the campus and housing areas which have various types and colors of flowers, so the bee diversity index values in the three areas are different.

Bees contribute greatly to pollinating plants in agricultural areas [45]. However, the H value in paddy fields has the lowest value among the other four areas (1.05). It could be because there are not so many flowering plants in the paddy fields, which are a source of bee food. The lack of crops and flowering plants around agricultural areas is one of the factors in the decline in bee diversity. Bees depend on the availability of flowering plants because they are a source of food to sustain their lives[46]. The availability of resources in the form of flowers is also one of the main factors determining the level of diversity of bees in an ecosystem[47]: the more flowering plants, the more types and abundance of bees in that location.

Apart from the availability of flowering plants, other factors that cause low diversity and bee populations in agricultural areas are human activities that use insecticides to deal with pest problems. The use of insecticides will certainly affect the diversity and abundance of insects[48], especially bees[49]. According to research from Kovács *et al.*[50], excessive use of insecticides will reduce the bee population in an ecosystem, which will cause the local extinction of bees in that ecosystem[51]. Practically insecticides in controlling pest populations are still the main choice of farmers so far in controlling pest populations and attacks, especially in rice plants. Likewise, farmers in the rice fields used in this study still use insecticides to control populations and pest attacks on rice plants.

The insecticide used by farmers in the paddy fields used in this study was *a brand* containing the active ingredient *fipronil*. *Fipronil* is an active compound that is highly toxic to pollinating insects, especially bees, and can even cause death. It is confirmed by the statement from Kovács *et al.*[50], that exposure to insecticides *containing fipronil* in agricultural areas caused bee populations to decline. It is confirmed by research from Holder *et al.*[52] who found mass death of bees on sunflowers in France during the 1990s due to *fipronil*.

Even though the rice fields where the research was carried out still used insecticides to control populations and pest attacks on rice, the results showed that almost all types of bees from the five types of bees found in this study were found in the rice fields. It could be because bees can still collect pollen or nectar from insecticides as long as the flowering plants are exposed to insecticides in low doses (0.1 – 1%)[53]. This low exposure will not cause the bees to die directly, but they will accumulate these substances in their bodies[54].accumulation of *fipronil* is continuous[55].

Bees can indirectly overcome this by detoxifying the poison using its detoxification system. It consists of enzymes such as P450

*monooxygenase*, *glutathione transferase*, and *carboxylesterase* by changing or coding metabolic enzymes, metabolizing quercetin, a flavonoid contained in nectar[56]. However, it is possible that bees can still experience death if they continue to look for nectar in plants contaminated with *fipronil*[57]. Besides affecting individual bees, *fipronil* also affects bee colonies[58]. Bee colonies that are continuously polluted by *fipronil* can cause a reduction in the age of the colony. The existence of behavioral and physiological changes in the bodies of larvae found in colonies can interfere with their survival[52] and affect the vitality of the colony.

In addition to calculating the H value, this study also calculated the Simpson dominance index (D) value of bees found in the UAD 4 campus area, vacant land, rice fields, and housing. The highest D value was obtained in the residential area at 0.53 and the lowest in the vacant land area at 0.28. The dominance index values for housing and rice fields are categorized as moderate, namely around  $0.50 < C < 0.75$ . The value of D in the campus area and vacant land is categorized as low ( $0.00 < C < 0.50$ ) with a D values of 0.42 and 0.28. The high dominance index value in residential areas can be caused by bees dominating the area. The dominant bee in the residential area is *A. cingulata*. These bees were the most dominating in abundance compared to the other three species found in residential areas. It can occur due to flowering plants attracting bees from the genus *Amegilla* in residential areas. The flowering plant that attracts bees of the genus *Amegilla* is the cherry. Kersen has the pollen needed by *Amegilla* [59], and the cherry blossoms' color is white, which is the favorite color of *Amegilla* bees[60]. Although bees from the genus *Amegilla* like white flowers, these bees do not visit *euphorbia* or *Bougainville* flowers because the flowers found on these plants in residential areas are not white. In addition, bees from the genus *Amegilla* prefer to pollinate vegetable plants such as the *Solanacea* or *Cucurbitacea* families rather than ornamental plants [61].

The dominance index value in paddy fields is moderate, with a value of 0.50. It is because there are bees that dominate the area. The dominant bees in the paddy field are *A. cingulata* and *X. aestuan*. The two bees dominated the paddy fields compared to the other three types found in the paddy fields. It is because, in the rice fields, there are chili and cherry plants which are a food source for *A. cingulata* and *X. aestuan*. The chili plant has white flower color and is a vegetable plant that is one of the favorite food sources for *A. cingulate* [62]. Apart from chilies, there is also a cherry plant with white flowers, a favorite flower for *A. cingulata* and *X. aestuan* [63]. Even though these two types of bees visit the cherry trees, there is no

competition between them because the cherry plants produce more flowers on each tree, so they do not cause competition in finding nectar or pollen.

Dominance index values in the campus area and vacant land are low ( $0.00 < C < 0.50$ ) compared to residential areas and paddy fields. It is because the five types of bees have almost the same number of individuals in the two areas. The bees are often found on campus, and vacant land is from the genus *Xylocopa*. It is because, in the vacant land area and campus, cherry plants are a food source for bees from the genus *Xylocopa*. Both areas also found bees of the type *A. cerana*, *A. mellifera*, and *A. cingulata* with almost the same number of individuals. It could be due to the presence of several wild flowering plants in the two areas. Flowering wild plants found in both areas were the shy daughter plant and Israel grass, which is a food source for the Apidae family's bees.

Vegetation of flowering plants in these two areas is evenly distributed and widely spread so that bees visit both areas frequently more. Not only is the distribution of flowering plants a determining factor in the diversity and dominance of bees in an area, but also the even distribution of these flowering plants causes a more even distribution of the types of bees that visit. As a source of food for bees, flowering plants that are evenly distributed will make it easier for bees to find nectar, causing no dominance of just one type of bee in a particular location. The dominance index value is inversely proportional to the diversity index value [64]. If the diversity index value in an ecosystem is high, then the dominance index value will be low in that ecosystem, and vice versa.

## CONCLUSION

The conclusions of this study were: 1) The diversity of bees in the campus area of 4 UAD, rice fields, vacant land, and housing in Banguntapan District, DI Yogyakarta, showed a moderate level of diversity and 2) The type of bee with the most number of individuals was *Xylocopa aestuan* (118 individuals) and the fewest *Apis mellifera* (7 individuals).

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