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Socio-technical Aspects of Smallholder Beekeeping Adoption of *Apis cerana* in Wanagama Teaching Forest, Gunungkidul, Yogyakarta

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ABSTRACT

The successful rehabilitation of Wanagama teaching forests, which began in the late of 1960s, has created a distinctive forest ecosystem. Currently the forests become the habitat of Apis cerana, enterprised by the surrounding villagers to produce natural forest honey as a non-timber forest product. This paper aims to explore the adoption of smallholder beekeeping of A. cerana, the beekeepers' socio-economic characteristics, the potential and value of forest honey production, the distribution of bee-boxes inside the forests and potential tree sources of nectar and pollen. Data collection was carried out in July - September 2019 with in-depth interview techniques to 38 beekeepers. Field observations and ground checks were carried out on the sites where beekeepers were placing the bee-boxes in the forest. In addition, an analysis of aerial photograph images taken with drone was also carried out to identify the area of trees as sources of nectar and pollen. The results show that between 1982 and 2019 the development of the adoption of the A. cerana beekeeping increased significantly. The total production of honey from 506 bee-boxes reached 658 liters or 894.9 kg in year of 2018/2019. The number of bee-boxes placed in Wanagama was mainly distributed inside Compartment of 13, 17, 14, 16, 5, and 18. Acacia mangium, eucalyptus, cajuput and mahogany were the main types of nectar-producing trees, in addition to the abundance of flowering undergrowth plants. Many of the challenges faced by honey beekeepers included climate change, the shortage of nectar and pollen sources, pests and diseases and human disturbances. This research suggests the need for a social, institutional and technical approaches to increase the forest productivity as sources of nectar and pollen. It is suggested encouraging the smallholders to adopt beekeeping as the main livelihood alternatives in future and planting more trees in Wanagama forests.

Keywords: Bee forages, Forest rehabilitation, Non-timber forest product, Rural development, Socio demographic

Introduction

During the Covid19 pandemic, the demand for honey has reportedly increased. Honey is a functional food ingredient produced by honey bees, and is one of the natural sweeteners that can be used by humans without any prior processing. There are many benefits obtained from honey for health, such as reducing the effects of chemotherapy (Simamora *et al*., 2016), as an antibacterial (Huda, 2013), and as a raw material in the food and beverage industry (Suranto, 2004). Bees also have external effects, such as supporting the natural pollination of various types of agricultural and plantation crops so as to produce beneficial food production for farmers (Rucker *et al*., 2012). In Indonesia, honey is produced from several types of bees including *Apis andreniformis, Apis dorsata dorsata, Apis dorsata binghami, Apis cerana, Apis koschevnikovi, Apis nigrocincta, Apis florea, Apis nulensis*, and *Apis mellifera* (Novandra and Windyana, 2013). Except for *Apis mellifera*, these bee species are native Indonesians (Hadisoesilo, 2001).

Honey production data in Indonesia varies from source to source. In 2018, Indonesia's forest honey production records reached 147.274,03 liters or only 203 tons a year, mostly produced in Java Island (BPS, 2018). Other sources report that Indonesia's honey production estimates reach 4,000 tonnes annually, and about 75% of them are generated from hunting wild honey bees in the forest (Kuntadi, 2008). The consumption of honey

is estimated at 7,500 tonnes per year (Novandra and Windyana, 2013), far above the official production recorded in government agencies. Thus, it is certain that the gap of honey consumption is met from imports. In 2019, Indonesia imported 3.041 tons of natural honey from various Asian and African countries with an import value of US$ 12.5 million or equivalent to IDR 175 billion (BPS, 2019).

With a forest area that reaches 120.6 million ha or about 63% of the land area, the potential for developing honey bee production in Indonesia can still be maximized (Ministry of Environment and Forestry, 2018). The potential for food crops for pollen and nectar sources for honey bees in Indonesia is believed to be quite large. There are around 25,000 types of flowering plants that grow and develop well in Indonesia. In addition, the very large diversity of plant species provides sufficient nectar throughout the year (Rusfidra, 2006).

One of the forest honey producing areas in Yogyakarta is located in Gunungkidul Regency. This area has a variety of bee forage sources that are potential enough to be developed as a honey-producing area (Agussalim *et al*., 2017). In this province there is Wanagama Teaching Forest which has been successfully rehabilitated since the 1960s, creating a new forest ecosystem. Types of plants found in these forests include *Acacia mangium*, *Eucalyptus sp*, *Melaleuca cajuputi*, *Switenia sp*, *Tectona grandis*, *Gliricidia sepium* and various mixed stands (Ernawati, 2016). Wanagama is currently becoming the habitat for *Apis cerana* bees that have been adopted by villagers living around the forest. Initially, the bee is adopted individually, but then continues to grow until a beekeeper group was formed recently.

Research on the adoption of honey bees by villagers around the Wanagama Teaching Forest has not been much revealed, especially from the socio-economic and technical aspects. The various problems faced by beekeepers to increase adoption and scale of their business are still unknown. In fact, rural development, especially those based on agriculture and forestry, can be further enhanced through the development of the community beekeeping sector as non-timber forest products (Bila, 2020; Fernando, 1995; Kárpáti *et al*., 2010). This study aims to explore current conditions related to the socio-technical aspects of *A. cerana* beekeeping adoption by communities around the Wanagama Teaching Forest, including revealing the socio-economic characteristics of beekeepers, estimating production and production value of *A. cerana* honey bees, identifying the distribution of forest space utilization for apiculture and the potential of bee forage plants inside the Wanagama Teaching Forest. With this knowledge, it is expected that the development of forest villages based on non-timber forest products can be more developed in the future.

Materials and Methods

Description of the research location

This research is conducted in the Wanagama Teaching Forest and in Banaran Village, Playen District, Gunungkidul and the data were collected in June – September 2019. Wanagama has a total area of 622,5 ha which is dominated by hilly topography and is included in the geomorphology of karst hills in the Wonosari Valley zone. The characteristics of karst limestone are hilly reliefs and layered rock structures that cause the formation of underground caves or rivers. The soil solum in the Wanagama area is thin and rocky, which is dominated by a clay fraction with a lumpy soil structure. Soil types this forest are Mediterranean, Lithosol, Rendzina, Grumusol, and Alluvial (Supriyono, 2004). Wanagama forest is now becoming favorable habitat for any bees to forage, including *A. cerana* bees due to the availability of abundant sources of nectar, resin and pollen or pollen derived from forest plants, crops and wild plants. Other environmental factors such as altitude, temperature, humidity, sunlight intensity, and vegetation conditions also influence the abundance of *A. cerana* bees (Novita, *et al*., 2013; Widiawati *et al*., 2019; Rachmawati *et al*., 2014).

One of the villages around the Wanagama Teaching Forest is Banaran. This village was chosen as the research location because the majority of honey beekeepers come from the Banaran village. This village is located at an altitude of 150-200 meters above sea level, with a humidity level of 80-85%. The average daily temperature is 27.7° C, the minimum temperature is 23,2° C and the maximum temperature is 32.4° C. The total population of Banaran is estimated at 3.958 people with a fairly high population density of 527 people/km2. The area for settlement is 95 ha. Agriculture on dry land covers an area of 367.2 ha planted with *palawija*, combined with tree crops planted along the land boundaries and in the middle of the land, forming alley cropping patterns. Various sources of nectar and pollen as reported by Agussalim *et al*. (2017) in the Gunungkidul area are generally also found in this area, such as agricultural crops that produce nectar and pollen, for example corn, beans, and rice and papaya, cassava and chilies. Also, villagers plant trees around homegarden and dry land with the dominant types of teak, mahogany, acacia, turi, tayuman and several types of fruit plants, such as chocolate, oranges, guava, mango, rambutan, sweet starfruit, sapodilla, jackfruit, breadfruit. These plenty types of crops, fruit and perennial trees show that the area is potential as a honey barn (Agussalim *et al*., 2017).

The number of active beekeepers in this village is 38 families. Thus this number becomes the population of this research and all are included in the survey. In addition, a field survey was also carried out using GPS to collect coordinates of the apiaries where beekeepers located their stups (bee boxes), scattered inside the Wanagama

forest. Identification of the dominant types of nectar-producing trees was also carried out by analyzing aerial photographs obtained in July 2019 with an Unmanned Aerial Vehicle (fixed wing drone).

Procedures of data collection and analysis

Socio-demographic characteristics of beekeepers. Information about the socio-demographic characteristics of honey bee farmers was collected through interviews with beekeepers. The questions raised included birthyear, highest education attained, current main occupation, and the year firstly adopted bees in Wanagama. In addition, we asked about the uniqueness of the characteristics of beekeeping by conducting in-depth interviews with key figures and actors in the history of early-generation bee adoption. The data obtained were analyzed descriptively by tabulations, graphics and thematic analysis.

Estimated production and value of Wanagama honey in one harvest season. Sources of data on honey production in a year were obtained from 33 honey beekeepers. Five beekeepers were recorded as not producing honey in the research year. The data collected through interviews with honey beekeepers included cumulative forest honey production for one year period with an estimated harvest starting from the flowering season between September 2018 and June 2019. Beyond that months, it was the honey famine season as not many stands flowered and was the peak of the dry season. Honey harvested was usually stored in 460 ml Marjan glass bottles, so by asking how many bottles were produced during this period, the total amount of honey production could be estimated. The total volume in liters was converted into weight unit; a conversion rate of 1 liter of honey equals to 1.36 kg. The monetary value of honey was calculated by multiplying the total honey production with the selling price of honey which was generally determined by beekeepers, that is, IDR 250,000 per 460 ml in 2019.

The bee boxes distribution inside the forest area. Each farmer has a different number of bee boxes and places them in the Wanagama forest at various locations. The locations have their own names based on certain events or uniqueness agreed upon by local residents, which are then referred to as blocks. For example, it is called Blok mBledek because there was once a lightning strike (bledek) that struck a tree in the area. Each block was visited. With a GPS device the coordinates of each location were identified and then overlaid on the existing Wanagama map. With the combination of interviews and field observations, information on the number of beeboxes and how many bee boxes were colonized by bees was identified. The tool used was a tally sheet containing data on the name of the beekeepers, the coordinates of the stups, block names, and the number of the colonized and empty bee boxes. Descriptive analysis was carried out to explain the relationship between the distribution of apiary and the diversity of the forest stands as a source of food for bees.

Potential nectar source stands. The potential for stand sources of nectar and pollen in each block was determined by analyzing aerial photo images captured by fixed wing drone (unmanned aircraft) in July 2019. The aerial photo was interpreted to analyze the stand types and the area size of stand types. To determine the area of nectar-producing stands, delineation analysis of stand types and ground check were also carried out in the field. The results of delineation were used to explain the relationship between the potential area of stand types and the reasons for placing the stups in the blocks.

Results and Discussion

The characteristics of the beekeeping adoption

In Banaran village, the person who first adopted *A. cerana* bees in the Wanagama forest was Purwanto (74 years old). Purwanto received a direct mandate from Oemi Haniin, the founder of Wanagama to raise bees in the area of Compartment 17. In 1982, Wanagama established a forest areas for progeny testing of *Acacia mangium* on Compartment 13, 14, and 17. In that year, Purwanto began adopting bees in the Wanagama forest. However, until 1990 not many villagers had followed him. Starting in 1991, Hari Susanto (49 years old) also adopted *A. cerana* bees, which was then followed by others, bringing the number of beekeepers in 1992 to 18 families. However, the number of beekeepers did not increase until 2000. There was a significant increase in 2016, doubling the total number of families adopting bees to 42 people (Figure 2). There are currently two groups starting to involve in *A. cerana* adoption, namely the Sumber Rejeki Cooperative and the Sedyo Maju Farmer Group. At the time of this research, there were several beekeepers who were no longer active due to death, having other activities so that they only became members of the group without managing the stups in the forest.

When adopting bees for the first time, the average age of the beekeepers was 35,5 years, with the youngest being 15 years old and the oldest being 69 years old. Currently, their average age was 50,9 years, the youngest is 31 years old and the oldest is 76 years. Their experience of adopting bees has lasted between 1 – 37 years with an average of 15,8 years of adopting bees. The age variation at the start of adopting honey bees and the length of time they experienced this work shows that this alternative livelihood could involve various groups of generations (Table 2). This shows the continued adoption of beekeeping from the older generation to the younger generation and is a hallmark of the goal of sustainable development, where the benefits of natural resources are not only felt by one generation but are cross-generational with equal or higher value (Rivai and Anugrah, 2011).

In terms of their main occupation, only 7,9% of beekeepers made beekeeping as their main income source, while 92,1% only considered it a supporting income. Most of the beekeepers were farmers and/or farm laborers (52,6%), while others were traders, services and civil servants or retirees. From an educational perspective, most of them graduated from senior high school, followed by elementary and junior high schools. Only a few graduated from university (7.9%). Some research reported that several socio-economic factors affect the gross profit rate of beekeeping, namely income from outside the beekeeping business, the diversity of bee-derivative products other than honey, the experience of cultivating bees, the number of hives owned and the level of education (Doğan *et al*., 2020). These factors need to be considered so that the adoption of bee cultivation can be a profitable economic alternative in future.

Adoption characteristics of A. cerana bees in Wanagama

The smallholder beekeeping adoption and its honey processing have the following characteristics. *First*, knowledge about beekeeping and honey processing has been transferred from generation to generation through their parents. The young generation learns by doing in gaining this knowledge and skills through following and observing their parents in placing stups in the trees. However, the experienced one also mentoring their friends or neighbours through learning by doing. This traditional knowledge transfer is kept until now.

Second, the bees are colonized bee boxes or known as stups or *glodogan* and hung from tree

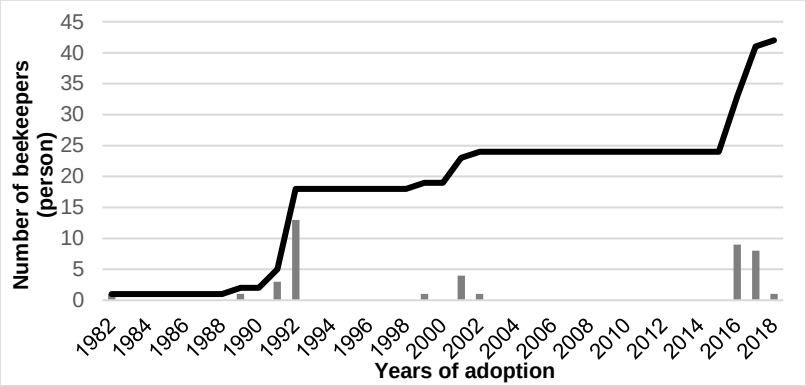

Figure 1. The accumulated number of beekeepers (line graph) and the number of villagers adopting bees every year (bar graph) between 1982 and 2019.

Table 1. Socio-demographic features of the beekeeping adopters in Wanagama

Characteristics	Description*
Current age (year)	
Average	50.9
Minimum	31
Maximum	76
Age first adopting bees (years)	
Average	35.2
Minimum	15
Maximum	69
Length of experiences (years)	
Average	15.8
Minimum	1
Maximum	37
Highest education (N=38)	
No education	1 (2.6)
Elementary school	11 28.9)
Junior high school	9 (23.7)
Senior high school	14 (36.8)
University	3 (7.9)
Main occupation (38)	
Beekeeping only	3 (7.9)
Cattle raiser/breeder only	2 (5.3)
Farmer and or farm labourer	20 (52.6)
Small entrepreneur/trader	4 (10.5)
Services: driver, ojol, carpenter	4 (10.5)
Village committee	1 (2.6)
Civil servant/retiree	4 (10.5)
Join the beekeeper group? Lebah (N=38)	
Yes	19 (50)
No	19 (50)

*Note: values in brackets are in percentage (%).

branches with a height of about 2 - 5 meters from the ground. The size of the bee boxes varies, generally measuring in length, width and height: 50 x 35 x 25 cm. Several new hives owned by the beekeeping herd are also placed under forest stands on iron legs so they can be moved easily. Some beekeepers place the new stup with the new queen by splitting old stup that have two or more queen eggs. There is no clear information how much successful this practice as many reports the failure to practices this splitting intervention. Otherwise, the stups will be colonized naturally, without any human intervention.

Third, the bees of *A. cerana* cultivated in Wanagama forest is without artificial feed, such as sugar. Bees are allowed to wildly suck nectar from flowers and leave armpits (extra floral), resins and pollen, both from woody stands and from understorey and agricultural crops. There is an informal agreement among the members of beekeepers not to feed the bees with sugar to maintain the quality of the Wanagama forest honey, even in the dry season when the nectar is so limited.

Fourth, the work of beekeeping is men-dominated job because of some a risky aspects. Apart from bee stings, the use of cigarette smoke to keep bees weakened when harvesting honey is also often used. These two reasons, stings and cigarette smoke, are not compatible with women's culture in the village. In addition, because of the way to place the stup at a certain height on a tree branch, this work was also deemed unsuitable for forest village women. Even in the process of extracting honey from the hive which is done at home, it is also done by men or husbands. Thus, the role of women in this beekeeping adoption is still limited.

Lastly, beekeepers generally extract honey by heating although some produce raw honey as well. For the heated method, the process is simply explained as follows: honeycombs containing honey that is harvested from the stups are brought home and heated at a maximum temperature of 60^0 C in a pan for about 15-20 minutes. Then, the heated honeycombs are gradually cooled and filtered to separate the honey from the hive. Honey extracted from the hive by heating is believed to have more remedies properties. They believe that the beehive contains not only honey, but also pollen and tree resin which when heated with honey will dissolve into one, thereby increasing the properties of the honey produced. Several studies have shown that heating honey at moderate temperatures and not for too long can produce honey with low viscosity and water levels, which slows down fermentation (Shapla *et al*., 2018). However, at high temperatures (>80^0 C) the heated process can reduce diastase enzyme and hydroxymethylfurfural compounds (HMF), which are parameters of honey quality (Shapla *et al*., 2018; Tosi *et al*., 2007). Generally, honey that is heated in this research is honey that has been extracted from the hive. Therefore, it is necessary to test whether the practice of heating honey with its hive at various temperatures and times produces honey of significantly different quality or not.

Problems faced by beekeepers

At present, there are challenges encountered by the beekeepers to enhance the adoption of *A. cerana* in the forests. Firstly, problems related to climate change; beekeepers feel that the air temperature is getting warmer and the rainy season is irregularly structured. The delay in the rainy season schedule can be seen from the behavior of the queen bees, which spawn male bee workers slower and less than usual. This has an impact on the increasingly limited colony growth. Another problem is related to environmentally unfriendly farmer behavior, such as land preparation by burning and the use of herbicides and pesticides and stups theft. The behavioral factors of farmers who burn litter for land preparation can also disrupt colony growth and drive bees out of the hive. In addition, farmers who use chemical pesticides and herbicides in plant maintenance often cause bees to migrate from their colonies. Also, lack of support for feed as a source of nectar and pollen due to logging of *Acacia mangium* stands in the past also affects the availability of feed sources, so that colony growth is not as massive as before. The presence of pests, especially large butterflies and mealybugs, on bee colonies has also been reported as the cause of bee colony migration. All of these factors are thought to reduce the productivity level of the bee colony. These factors require further solutions in the management of *A. cerana* bee adoption in Wanagama forest.

The problems faced by beekeepers are not only unique to Gunungkidul, but also faced by beekeepers in other countries, such as Turkey as reported by Vural and Karaman (2010). These problems include a decline in the quality of the queen bee in producing tillers, a lack of standards for beehives, problems related to the use of pesticides, the placement of suitable apiaries, and weak marketing which results in inefficiency in beekeeping. In addition, honey cultivation is not considered a commercial scale economic activity and technical knowledge of honey cultivation is still low. To increase the economic role of honey, efforts should be made to increase the efficiency of the beekeeping business by increasing feed sources, changing hive types and improving the marketing efficiency (Vural and Karaman, 2010).

Estimated total production of honey and its monetary value. Currently, the number of active beekeepers is 33 people with total ownership of the stups filled with bee colonies of 460 stups. There are 45 stups owned communally by farmer groups, namely the Sumber Rejeki Cooperative and KTH Sedyo Maju. The honey production from communal ownership becomes the group's cash earnings. The total honey production during the flowering season in Wanagama forest in September 2018 – June

2019 is estimated to produce 1,431 bottles of Marjan size (size 460 ml/bottle) (Table 2). Thus, the total honey production produced is 658 liters or 894.9 kg. Of the total honey production, it is estimated that the total gross income value is IDR 371,787,000. This total revenue comes from the sales value of IDR 565,000/liter multiplied by the total honey production in that period. The market price for Wanagama honey is admittedly higher than the market price for other forest honey in Indonesia, which ranges from IDR 150,000 - 300,000/liter.

Each beekeeper has a different number of stups and a variety of honey production. Hari Susanto, for example, has the largest number of stups, as many as 69 with honey production a year reaching 359 bottles or 165.1 liters and an estimated income of IDR 93,304,000 (see Appendix 1). If the production mean per stup is calculated, one colony of his stup can produce 5 bottles or 2.4 liters or 3.3 kg. This production per stup has monetary value of IDR 1,352,200 per year. Meanwhile, out of 33 beekeepers, on average, one stup produces 4 bottles or 2 liters or 3 kg of honey with a monetary value of IDR 1,054,000 in a year, so the average income of beekeepers per year is IDR 14,756,000. The honey production per stup in Wanagama is slightly smaller than the production of *A. cerana* honey from the tomato and strawberry farming areas in West Sumatra, which can produce honey from 2.7 to 3.9 liters/stup (Pasaribu *et al*., 2017).

Several factors may affect the variation of honey production in one stup, including: maintenance intensity, which is how often the breekeepers supervise and maintain the hanging

Table 2. Estimation of forest honey production in the seasonal time between Sept. 2018 and June 2019

Number of beekeepers	Number of stups		Volume			Revenues (x IDR 1.000)	
	Total	Average	Bottle	Liter	Kg	Total	Average
Individuals:							
33 beekeepers	460	14	1395	641.5	872.4	362.431	10.982
Communal:							
Sumber Rejeki	35		24	11	15	6.237	6.215
Sedyo Maju	10		12	5.5	7.5	31.19	3.107
Total	505		1431	658	894.9	371.787	

Source: Table 3.

Table 3. List of breekeepers who are still actively adopting *A. cerana* bees in the Wanagama Teaching Forest and the estimated production of honey harvested in the period of September 2018 – June 2019.

Name	Number of colonized stups	Volume/year			Estimated revenue (xIDR 1000)
		bottle	liter	kg	
1. Hari Susanto	69	359	165.1	224.6	93.304
2. Sugiyo	50	60	27.6	37.5	15.594
3. Supriyanto	40	130	59.8	81.3	33.787
4. Suramto	35	70	32.2	43.8	18.193
5. Sugiman	30	50	23.0	31.3	12.995
6. Abdul Majid	30	42	19.3	26.3	10.916
7. Purwanto	25	60	27.6	37.5	15.594
8. Budi Waspada	19	19	8.7	11.9	4.938
9. Hardi Setiawan	17	15	6.9	9.4	3.898
10. Edi Purnawan	15	45	20.7	28.2	11.695
11. Suparno	15	40	18.4	25.0	10.396
12. Wito	13	32,5	15.0	20.3	8.447
13. Edi Suyanto	10	45	20.7	28.2	11.695
14. Sartono	10	48	22.1	30.0	12.475
15. Supanto	10	25	11.5	15.6	6.497
16. Sukeni	10	30	13.8	18.8	7.797
17. Ngatiran	5	20	9.2	12.5	5.198
18. Satiman	5	15	6.9	9.4	3.898
19. Sujarwadi	5	50	23.0	31.3	12.995
20. Suboko	5	10	4.6	6.3	2.599
21. Wiyono	5	5	2.3	3.1	1.299
22. Sumargiyono	5	15	6.9	9.4	3.898
23. Sumadi	5	20	9.2	12.5	5.198
24. Suharman	4	7	3.2	4.4	1.819
25. Agus Sudarto	4	16	7.4	10.0	4.158
26. Wakiman	3	24	11.0	15.0	6.238
27. Yudi Prabowo	3	50	23.0	31.3	12.995
28. Jumrodin	3	50	23.0	31.3	12.995
29. Maryanto	3	6	2.8	3.8	1.559
30. Jumiran	3	15	6.9	9.4	3.898
31. Suminto	2	8	3.7	5.0	2.079
32. Juhari	1	10	4.6	6.3	2.599
33. Sariman	1	3	1.4	1.9	780
Owned communally:					
1. Sumber Rejeki	35	24	11.0	15.0	6.237
2. Sedyo Maju	10	12	5.5	7.5	31.19
Total	505	1431	658.0	894.9	371.787

stup. The more they depend on their livelihoods on honey beekeeping, the higher the intensity of supervision and guarding. On the other hand, the more dependent on other income, for example those whose main income is from cattle breeder, the lower the intensity for monitoring honey bees and their production. In addition, choosing the placement of the stups in a location with less abundant feed availability around the stups can also affect honey production. The frequency of harvesting honey also determines the size of honey production per stup. Generally, they harvest 2 - 3 times during the honey harvest season for the same stup. Honey production may be disrupted by the activities of other farmers burning litter or straw for food crop preparation or by spraying pesticides or herbicides, thereby killing the bee colony. In the end, the size and number of nests in one stup colony will determine the honey production; the larger the size and number of nests, the higher the honey production.

Stups' distribution. Table 3 presents stups filled with bee colonies during field observations in August 2019 with a total number of 519 spread over 16 blocks and six plots of eight compartments (Plots 5, 6, 7, 13, 14, 16, 17, and 18.). The number of these huts is slightly more than the ones filled with colonies in the previous year. The total number of hives including the empty ones is estimated to be 2,076. The estimation of the total number of hives is based on the assumption that the community believes that every four hive placed in the forest will generally result in one hive filled with bee colonies. Meanwhile, the other three huts are still empty and will be filled when the colony is separated naturally or with the help of breeders. In one bee colony it is possible to produce 2 - 6 eggs of the prospective queen which will move after hatching. How the development mechanism of bee colonies still requires further research in the future.

The number of bee boxes in one Block indicates the intensification of honey bee cultivation in the area. For example, the number of bee blocks in Compartment 13, 14 and 17 is more than in Compartment 5 and 18. Compartment 13 is area where the distribution of the stups filled with honey bees at most, 169 stups, followed by Compartment 17 with 164 and Compartment 14 at 147, while the least are Compartment 5 and 18 (Table 3). This is related to the abundant food sources of *A. cerana bees* in Compartment 13, 14 and 17 (Pamungkas, 2019).

Placing stups in these blocks is believed to be correlated with the presence of understorey plants and stands of nectar source trees, both flowering (floral) and non-flowering (extra floral). For example, on plot 14, research conducted by Dahlan (2019) found that there were 57 types of understorey plants around the apiary (location of the stup) and 28 species with the highest density were found at the location of the apiary center point, that is, 48,000 plants/ha. There are 8 types of flowering understorey visited by honey bees, including *Mimosa pudica*, *Fimbristylis dichotoma*, *Polytrias amaura*, *Ageratum conyzoides*, *Ipomea triloba*, *Passiflora suberosa*, *Oxalis barrelieri*, and *Sida Sp*. The study also reported that bee visiting activity on understorey flowers was highest in the morning, namely 13,4 individuals/m^2 and decreased during the day (7,4 individuals/m^2) and in the afternoon (2.8 individuals/m^2). In addition, the farthest home range of bees was recorded up to 300 meters from the apiary location, although it is very rare (see Dahlan, 2019).

Apart from understory plants, there are four types of tree stands reported by honey beekeepers as a source of nectar and pollen for their *A. cerana* bees, that is, *Acacia mangium, Eucalyptus sp*, Switenia sp, and *Melaleuca cajuputi*. Especially for *A. mangium*, the source of nectar is not only out of the flowers, but from the axillary leaves. Purwanto and other beekeepers have been observing this phenomenon for a long time, so they highly recommend expanding and increasing the stock of *A. mangium* stands. Even Hari Susanto and several other residents maintain mangium's natural regeneration that grow wildly in

Table 3. Distribution of bee-boxes per blocks inside the Wanagama forests

Compartment	Blocks	Number of stups	
		Total	Colonized
5	*Banyu Numpang*	**56**	**14**
13	*Ngagro & Kaliyoso*	300	75
	Ngepoan	184	46
	Ngrengas	132	33
	Watu Galeng	60	15
	Sub total	**676**	**169**
14	*Buk Duwur*	256	64
	Ngasinan	140	35
	Ngreokan	128	32
	Plesetan	36	9
	Ndase Ngasinan	28	7
	Sub total	**588**	**147**
16	*Sangkar Burung*	**68**	**17**
17	*Tuk talang*	220	55
	Mbledak	184	46
	Sriwitan	176	44
	Mbatang Merak	8	2
	Sub total	**656**	**164**
18	*Lor Makam*	**32**	**8**
Total		**519**	**2076**

Source: Pamungkas (2019).

Table 4. Aerial imagery analysis of vegetation land cover where apiaries are located)

Petak	Vegetasi dominan	Luas (ha)	%
5	Gliriside (P)	41.0	48.2
	Tegakan Campur (NP)	23.9	28.0
	Akasia (ENP)	7.1	8.4
	Mahoni (NP)	5.2	6.1
	Lahan Terbuka	4.2	5.0
	Lainnya	3.8	4.5
	Jumlah	85.2	100
13	Jati (P)	28.6	31.2
	Eucalyptus (P)	19.9	21.7
	Tegakan Campur (NP)	18.8	20.5
	Lahan Terbuka	14.3	15.6
	Akasia mangium (ENP)	3.9	4.2
	Lainnya	6.2	6.8
	Jumlah	91.6	100.0
14	Bare land	25.6	28.2
	Teak (P)	19.8	21.9
	Acacia mangium (ENP)	18.6	20.6
	Mixed stands (NP)	10.4	11.5
	Eucalyptus Sp (P)	5.3	5.9
	Others	10.8	11.9
	Sub total	90.5	100
16	Mahagony (NP)	24.6	34.5
	Shrubs	21.9	30.7
	Teak (P)	10.7	15.0
	Mixed stands (NP)	4.3	6.1
	Bare land	3.7	5.2
	Others	6.2	8.6
	Sub total	71.4	100
17	Teak (P)	13.7	21.2
	Acacia mangium (ENP)	11.5	17.7
	Bare land	10.7	16.5
	Eucalyptus Sp (P)	8.0	12.3
	Agroforestry (NP)	7.0	10.8
	Gliricidia (P)	6.2	9.6
	Others	7.7	12.0
	Sub total	64.7	100
18	Acacia mangium (ENP)	20.8	27.4
	Agroforestry (NP)	14.7	19.5
	Mahagony (NP)	12.4	16.3
	Bare land	9.7	12.8
	Teak (P)	9.2	12.2
	Eucalyptus (P)	3.6	4.8
	Others	5.3	7.1
	Sub total	75.7	100

Note: P= Pollen source; N= Nectar source; E= Nectar extra floral.

Compartment 17 and put the restriction banners, so villagers are not allowed to cut down for animal feed.

Table 4 presents the results of the aerial photo image interpretation which found the five dominant land use types in the compartment where apiaries were placed by the beekeepers. In each compartment, where the apiary was laid, there was always some types of stand that the bee likes. For example, in Compartment 14, there are stands of *Acacia mangium* and *Eucalyptus sp* covering an area of 18,6 and 5,3 ha, respectively. In Compartment 16, mahogany stands are very dominant, covering an area of 24,6 ha, while in Compartment 13 *Eucalyptus sp* is occupied an area of 19,9 ha. Teak stands are also quite dominant in the six compartments, but according to the beekeepers, teak stands are reported to be less supportive as a source of nectar. Sukmasetha (2017) shows that the increase in colony weight of bees keep under *Eucalyptus sp* stands tends to be higher than those keep under teak stands, an increase by 102.3% compared to 62.6%. The increase in honeycomb area under Eucalyptus stands also tends to be higher than under teak stands. Agroforestry land use patterns also include those that have the potential as a source of animal feed (Syahidah, 2013). The results of image analysis show that Compartment 17 and 18 have many parcels of agroforestry land uses. Further research on the activity of bees in each tree stand around the apiary needs to be done so that more accurate and validated information is obtained about farmers' assessments of stand preference as the main producer of nectar and pollen.

Conclusions

This study aims to gain better understandig the adoption of *A. cerana* bees by the Banaran beekeepers living around the Wanagama Teaching Forest. This adoption has begun since 1982 and has grown in popularity in the last five years (2016 - 2019) with the number of beekeepers increasing from 18 in 1992 to 42 in 2019. The beekeeping becomes livelihood alternative for intergenerational communities with a range of experience raising bees between 1 to 37 years and transfer to the next generation through traditional knowledge. However, only 7.9% of the beekeepers make beekeeping their

main income. In addition, honey production in 2018 – 2019 reaches of 658 liters or 894.9 kg a year from total 505 stups. The largest distribution of stups in the forest is in Compartment 13, 17 and 14, with stands of nectar and pollen producing trees, mainly eucalyptus, mangium, mahogany, teak and other understorey plants as well as agroforestry. The total monetary value earned by all beekeepers is estimated at IDR 371 million per year. To increase the adoption of *A. cerana* bees into a sustainable business and production, it is imperative to remove the barriers of the adoption by, for example, increasing the awareness of the farmers not to use fire in land preparation, preventing the usages of chemical pesticides/herbicides, enriching the flowering trees as sources of nectar and pollen, and diversifying the derivative products of honey such as processing honeycomb waste into beewax and other secondary products. Also, it is suggested for the management of Wanagama to support the quality of honey and certification of organic honey so that the consumers will be more confident about the quality of the honey produced. In addition, beekeepers institutions need to be improved so that the honey product marketing chain can be absorbed by the market place more quickly.

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