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Abstract. In order to maximize the potential of wild honey bee *Apis cerana*, there have been ongoing breeding efforts conducted in three coconut plantations in Padang Pariaman, West Sumatra. The searching for wild honey bee colonies was performed in potential sites in Lancang, Batu Gadang and Pakandangan Villages. There were 20 colonies found in the wild and relocated using hive-to-stub method; 10 colonies were then bred in its original sites while other 10 stubs transferred into farm located in Pakandangan Village. To support the breeding efforts, there was inventory survey carried out at the surrounding of breeding farms to list plants that are food sources for honey bee. From total 60 bee hives found, 32 of them built inside the hollow of dead timber, 18 nests existed in living tree crevices and other 10 nests in various hollowing structures. The successfulness of breeding effort using hiving method before transferred to distance farming location reached 76.66%, much higher than letting the stubs in the original location of wild nests (23.34%). Number of honey combs grew on the first month after transferred was variable between 3-9 frames and 124 frames (35.38%), the breadth of comb up until 75%. Plants for food sources were enlisted until 65 species, in which 20 of them categorized as cultivated and year-round flowering plants.
Keywords: *Apis cerana*, wild honey bee, hiving, breeding effort, nesting sites

1. Introduction

Honey bee *Apis cerana* (Hymenoptera: Apidae) is also known as Eastern honeybee. This bee species nests within the tree hollow and crevices in the building [1]. Its colonies were frequently found inside the hollows of dead tree of coconut (*Cocos nucifera*) and areca palm (*Areca catecu*). The colonies were also observed occupying abandoned rodent cavities, termite mounds, electric poles and used chairs. The members of colonies enter and exit the nests through the entrance which found to be variable in number and size [2]. A nest of honeybee consists of several combs which main functions are to store honey, pollen and raise the young individuals. Cells that compose a comp are reusable for the next breeding cycle [3].

Honeybee *A. cerana* colonies are found living wild in various habitats in West Sumatra. Colony density of honeybee within the lowland polyculture plantations can reach 5.2 colonies per hectare [4]. These colonies have potential to produce honey, pollen, wax and become pollinators in the various plantation. A single colony of *A. cerana* can yield 1-1.5 kg honey per month [5]. Until currently, this

potential has not been optimally utilized due to the wildness of the bee species and technical difficulty in harvesting bee nests that located in difficult-to-reach cavities.

The potential of honeybee *A. cerana* in Padang Pariaman District of West Sumatra can be maximized through captivity and breeding effort. Effective and rapid relocation of bee colonies from the wild into breeding stubs can use the hiving method. This method involves relocating whole bee colony into a breeding stub [6]. A successful relocation is indicated by the staying of colony inside the stub and begin to construct the combs within available frames. The relocated colony then can be then optimized to produce honey and other bee products, as well as pollinator.

The placement of breeding stubs is one among determinant factors for the successful of hiving method. Stubs used in this method can be placed in the proximity of original nests or at other appropriate places elsewhere. The colonies of *Trigona* spp that were treated with hiving method and placed at the nearby of their original nest reached 90% successful rate of relocation [7]. Meanwhile, the successful rate of hiving method applied with different placing location was still limited to knowledge. This study aimed to find out the successful rate of the relocation of *Apis cerana* colonies using hiving method, in which the breeding stubs placed either in the proximity of former natural nests or in new locations.

2. Materials and Methods

2.1. Study Site and Sampling Method

The field observation had been conducted from March to November 2018 at the community coconut plantations located in three different villages in Padang Pariaman Regency; Pakandangan Villages in 2x11 Enam Lingkung Sub-regency, Lancang Villages in VII Koto Sungai Sarik Sub-regency, and Batu Gadang Kuranji Hulu in Sungai Geringging Sub-regency. Meanwhile, data analysis and identification of food source plants were performed in Botanical Laboratory, Educational Biology Study Program, STKIP PGRI Padang, West Sumatra.

This study primarily used hiving method, by relocating whole colony of wild *Apis cerana* from their original nest into a breeding stub. The breeding stubs were with 40x20x30 cm dimensions, in which can accommodate nine frames. This method was arranged with two treatments and ten repetitions. In the first treatment, the breeding stubs with relocated colonies were removed from its original nest location while in the second treatment the stubs stayed around after colonies relocated.

The searching for *A. cerana* colonies was performed at community coconut plantations. As soon as a nest found, data collection briefly pursued i.e. the type and species of the nesting site, bark diameter and the height of nest entrance from ground surface. Relocation procedures were commenced through three following steps as detailed bellow.

Preparation. Nesting site was firstly cleaned to clearly see the nest entrance and flying direction of the workers. An approximately 80 cm pole was used to support the stubs. In the treatment where stubs located around the original nest, the poles erected within 100 cm radius of original nesting site. The stub was set in a way that its entrance facing same direction with the natural nest. The cover of stub was left ajar.

Commencing the hiving method. Colony relocation was through the hiving method [6]. The wall that enclosed the natural nest was thoroughly sawed before carefully opened to expose nest cavity and combs. All combs were then detached from nest walls, freed from all adult bees before two combs contained the most bee individuals with early reproductive stages (i.e. eggs, larvae and pupas). Attach the base of chosen combs into the frames within the stub, tighten with thread. The frames were positioned inside the stub similarly with the position of combs in its original nest; the stub cover should make gap with stub body at this point.

Take out all other combs from the nest, positioned them atop the stub cover. Wait for 10-15 minutes to see if the workers make crowd at certain point on the combs in order to pinpoint the queen whereabouts. Instinctively, the workers will surround the queen during emergency situation so they can protect her from any imminent danger. Upon spotting a suspected crowd, lift them all carefully and place it inside the stub through the slight-opening lid. Extend the waiting time to see if the

workers make another crowd, which may indicate the queen. Treat the next crowd in similar way to ensure the queen placed inside the stub body. The relocation of queen will be considered successful indicated from the summoning of all other workers into the stub body to follow their queen. After all workers gather inside the stub, close the lid steadily to enforce the colony using provided nest entrance. Wait for a moment to calm the colony inside the stub before commencing the next step explained below.

The maintaining. All relocated colonies then maintained at two types of location; first in the proximity of each original nesting site and second at the breeding center in Pakandangan Villages. The stubs contained bee colonies positioned at the top of pole in respective treatment location. The removal of stubs onto their supporting pole was performed during night time to minimize disruption to the relocated bee colonies. The stubs were then left undisturbed for a month to allow the colonies adapt with their new nesting places before the weekly observation started. In addition to the nesting tree plant, all flowering plants visited by bees within 500-meter radius from the breeding stubs, especially in Pakandangan Villages were also collected and identified.

2.2. Measured Parameters

Nesting site. Sites that used by *A. cerana* colonies were recorded. For nest made within the tree bark, data collection included bark diameter and the height of nest entrance from ground surface.

The successful of hiving method. It was determined from total wild *A. cerana* colonies that still stay in the breeding stubs after a month of relocation.

Nest development. This was measured from the formation of new combs within the stubs' frames, by excluding any new cell formed in original combs relocated from the wild nests. This measurement was mediated by establishing some criteria through modifying the calculation of comb width per frame width [8]. The criteria were stated as follow; the comb width more than 76%, between 50-75%, between 26-51%, between 1-25% and 0%.

Food source plants. The plants were identified and grouped according to their status toward honeybee. The identification process was guided with relevant literatures [9,10], while their status as either source of nectar, pollen or both was determined with separate guidance [11].

2.3. Data Analysis

Descriptive statistical analysis was used to detail the characters of nesting sites, number of wild *A. cerana* colonies that successfully adapted into the breeding stubs and the development of new combs within stub's frames that defined according to above criteria. Food source plants were grouped into three categories; seasonal flowering plants (termed as TBM), perennial flowering plants (termed as BST) and flowering plant depending on growing season (termed as TMT).

3. Results and Discussion

3.1. Natural nesting sites for Apis cerana

The wild *Apis cerana* place their colonies within the plant cavities and other hollowed locations (Table 1). Nests were observed more within the cavities of dead trees (32 nests) with most of them (25 nests) recorded from dead areca palm trees (*Areca catecu*). Four among ten colonies that used non-plant structures for nesting were observed built within the space under the roof of plantation huts. The height of nest entrance from ground surface and diameter of tree bark used for nesting were variable.

The observation on natural colonies of *A. cerana* in this study was in line with what previously observed [2]. Therefore, it firmly confirmed the preference of wild *A. cerana* for building nest within the natural setting. Most of the colonies were built within the hollow of areca palm. The dead bark of areca palm is usually fit with many criteria needed for building the nest for wild honeybee colony. The cortex section of the areca palm bark will decay and disintegrated after it dead, leaving a long hollow across the inner section of the bark. The volume created by this hollow was relatively spacious, with measurement of 16 cm in diameter and 40 cm height can make up to 8,038.4 cm^3 or equal to 8-liter volume. This is sufficient enough to accommodate a number of combs. Wild colonies of *A. cerana* are known to inhabit nest cavity with volume 2.75 - 110 liter [12]. Meanwhile, this study also revealed

that honeybee *A. cerana* could also occupy open space. They attached the combs of their nest under the roof and within the walls of huts erected amidst the community plantations. These huts were infrequently used by the owners, hence this situation hinting that *A. cerana* can live within human-affected habitat.

Table 1. Nesting aspects of wild *Apis cerana* at coconut plantation in Padang Pariaman Regeny, West Sumatra

No	Nesting site	Plant condition		Bark Diameter (cm)	Height of nest entrance from ground surface (cm)
		Living	Dead		
1	*Areca catecu* (areca palm)	1	25	18.62 ± 11.58	250.28 ± 252.44
2	*Ceiba pentandra* (kapok)	1	0	20.38	1.54
3	*Cocos nucifera* (coconut)	5	4	33.33 ± 13.95	83.37 ± 61.90
4	*Durio zibetinus* (durian)	2	0	50.31 ± 9.91	102.5 ± 48.79
5	*Ficus* sp. (fig)	1	0	65.61	122
6	*Garcia mangostana* (mangos)	2	0	49.84 ± 13.73	121.5 ± 77.07
7	*Manggifera* sp. (wild mango)	1	0	94.26	250
8	*Phithocellobium lobatum* (bitter bean)	2	2	31.05 ± 9.45	170.36 ± 153.58
9	*Pterosperma blumeanum* (Bayur)	0	1	0*	10
10	*Syzygium aromaticum* (clove)	1	0	21.65	23
11	*Syzygium jambos* (Jambak)	2	0	67.83 ± 57.19	163.0 ± 151.32
	Total	18	32		
	Non-plant structure				
1	Timber beam		1		30
2	Rice chest		1		50
3	Huts		4		308.75 ± 140.62
4	Termite mount		2		117.5 ± 95.46
5	Pile of coconut coir		2		12.0 ± 2.83
	Total		10		

*= the height of tree stump after cut reach only 60 cm from ground surface

Table 2. Condition of relocated colonies during 30 days of observation

Location	Stubs placed in original nesting site			Stubs placed elsewhere			Total
	Success	Failed	Total	Success	Failed	Total	
Pakandangan	4	6	10	8	2	10	20
Lancang	3	7	10	7	3	10	20
Batu Gadang	5	5	10	8	2	10	20
Total	12	18	30	23	7	30	60

3.2. Natural nesting sites for Apis cerana

Thirty-five out of sixty colonies of *Apis cerana* that relocated into the breeding stubs using hiving method had been staying in their new nest for a month after relocation (Table 2). The relocation of wild colonies of *A. cerana* into the stubs that later placed in far from their original nesting site was more successful (23 stubs) compared than to those that placed in the adjacent of original nesting location (12 stubs).

By the rate of more than 50% (35 out of 60 nests) wild colonies were successfully relocated into the breeding stubs, it indicated the effectiveness of hiving method when combined with the placing of stubs elsewhere of original nesting site. The hiving method actually inflicts serious disturbs to bee colonies as it forces them to move into artificial breeding stubs. This frequently causes the death of

young bee individuals and the loss of food reserved in the nests. All of these impose stress to whole colony members, which in turn make the queen and her colonies opted to stay within the stub waiting for their scouting workers recognize their new environment and adapt to it. This can later mean in two ways; the colony can escape after they familiarized with their new environment whenever the stress suffered by the colonies continued or they eventually accept the breeding stubs as their new nest and resume the living of the colony [13].

3.3. Nest Development

As many as 247 frames out of total 351 frames from 39 stubs had been filled with combs (Table 3). In average, the frames filled mostly with comb with criteria 75% (3.18 combs) and the least frame filled with comb with criteria 25-50% (1.0 comb). One of thirteen colonies in Lancang Villages and two of twelve colonies in Pakandangan Villages had produced the queen cells within their combs.

Bee colonies attempt to maintain the development of their hives to adapt to the size of the cavity where the nests located. The comb is initiated from the base of its attachment where the new cell then built atop the old ones to finally form semicircle pattern within the frame. This process continued until the layer of cells fully filled the space within the frame. The first month of observation revealed that three out of thirty-five successful relocated colonies had produced cells for the future queens. Normally, the forming of queen cell is determined by the age and maturity of the nest. It was observed in this study, however, the forming of queen cell could also be interpreted as a reaction upon the stress inflicted from the nest relocation.

Table 3. Number of colony and width of comb developed within the frame during 30 days of observation

Location	No. of Colony	Comb width (%) per number of frame					No. Empty Frame	Total
		> 75%	50-75%	25-50%	< 25%	Total		
Lancang	13	52*	9	13	16	90	27	117
Pakadangan	12	30*	11	12	12*	65	43	108
Batu Gadang	14	42	16	14	19	92	34	126
Total	39	124	36	39	47	247	104	351
Average	13,00	3,18	0,92	1,00	1,21	6,33	2,67	9,00

*= queen cell observed

3.4. Food source plants in the surrounding of breeding location of Apis cerana

There were 65 plant species within the surrounding of *Apis cerana* breeding farm in Pakandangan Villages, where thirty of these plants classified as cultivated species (Table 4). Among those cultivated species, coconut, areca palm, chocolate and corn were dominantly observed within the community plantations and gardens. Coconut and areca palm became continuous source of nectar and pollen for bee as they flowered all year-round, while corn only provided food for bee during its growing season.

The breeding effort that took place among coconut plantations also gave advantage in supporting the availability of food source for bee colonies. Coconut and areca palm produce flowers all year-round which ensures food supply for the colonies. A coconut tree can have up to 12 bunches of flowers while areca palm is up to five [14]. One inflorescence flower bunches can be filled with 20-40 panicles, in which around 20-60 female flowers and 5,000-12,000 male flowers arranged within [15].

Other wild plants that naturally exist inside the coconut plantations also have important role in supporting the breeding of *A. cerana*. Thirty-five wild plant species which are considered as weed plants can actually be the source of nectar and pollen for honeybee. Most of them can flower for most of the time in a year. Food provision on bee colony was thought to be an important factor in achieving the successful production while also maintain the colony population [16]. The composition of food source plants should always be checked in balance composition between 60% nectar producing plants and 40% pollen producing plants. Failing in keeping this ratio may result in the disruption of colony condition and hampering the expected production rate.

Table 4. Food source plant identified from around breeding location in Pakandangan Villages

Family/species		Plant Status		Type of food		Flowering time
Scientific	Local name	Cultivated	Wild	Nectar	Pollen	
1	**2**	**3**	**4**	**5**	**6**	**8**
I. Achantaceae						
1.*Asystasia coromandeliana*	-	-	√	√	-	BST
II. Anacardiaceae						
2. *Mangifera indica*	Mangga	√	-	√	√	TBM
3. *Mangifera* sp.1	Ambacang	√	-	√	√	TBM
4. *Mangifera* sp. 2	Ampolam	√	-	√	√	TBM
5. *Mangefera* sp 3	Kuini	√	-	√	√	TBM
6. *Spondias pinnata* Kurz	Kedongdong	√	-	√	√	TBM
III. Arecaceae						
7. *Areca catecu*	Pinang	√	-	√	√	BST
8. *Cocos nucifera*	Kelapa*	√	-	√	√	BST
IV. Asteraceae						
9. *Ageratum conyzoides* L	Sibusuak	-	√	√	√	BST
10. *Ageratum hostonianum* Mill	Sibusuak	-	√	√	√	BST
11. *Clibadium surinamens*	Karinyuh	-	√	√	√	BST
12. *Eupatorium inulifolium*	Karinyuh	-	√	√	√	BST
13. *Eupatorium odoratum*	Karinyuh	-	√	√	√	BST
14. *Mikania micrantha*	Aka-aka	-	√	√	√	BST
15. *Siplanthes iabadicensis*	Subang-subang	-	√	√	√	BST
16. *Siplanthes paniculata*	Subang-subang	-	√	√	√	BST
17. *Tridax procumbens* L	Subang-subang	-	√	√	√	BST
V. Bombacaceae						
18. *Durio zibetinus*	Durian	√	√	√	√	TBM
VI. Caricaceae						
19. *Carica papaya*	Papaya	√	√	√	√	TMT
VII. Capparidaceae						
20. *Cleome rutidosperma* DC	-	-	√	√	√	BST
21. *Cleome viscose* L	-	-	√	√	√	BST
VIII. Convolvulaceae						
22. *Calystegia sapium*	-	-	√	√	√	BST
23. *Ipomoea triloba* L	-	-	√	√	√	BST
IX. Cucurbitaceae						
24. *Citrulus vulgaris*	Semangko	√	-	√	√	TMT
25. *Momordica charantia*	Pario	√	-	√	√	TMT
26. *Cucumis sativus*	Mentimun	√	-	√	√	TMT
X. Cyperaceae						
27. *Cyperus brevifolius* Hassk	Rumput teki	-	√	√	√	BST
28. *Cyprus kylingia* Endl	Rumput teki	-	√	√	√	BST

Family/species		Plant Status		Type of food		Flowering time
Scientific	Local name	Cultivated	Wild	Nectar	Pollen	
1	**2**	**3**	**4**	**5**	**6**	**8**
XI. Euphorbiaceae						
29. *Aleurites moluccana*	Kemiri	√	√	√	√	TBM
XII. Graminae						
30. *Oryza sativa*	Padi*	√	-	-	√	TMT
31. *Zea mays*	Jagung*	√	-	-	√	TMT
32. *Leersea hexandra*	Rumput banto	-	-	-	√	BST
34. *Cynodon dactylon* (L.) Pers	Rumput pahit	-	√	-	√	BST
35. *Echinochloa colanum* (L.) Link	Rumput	-	√	-	√	BST
XIII. Labiatae						
36. *Hyptis brevipes*	Katen-katen	-	√	-	√	BST
37. *Hyptis capitata*	Katen-katen	-	√	-	√	BST
38. *Leucas lavandulaefolia* Smith		-	√	-	√	BST
XIV. Lauraceae						
39. *Cinnamomum burmanii*	Kulit manis	√	√	√	√	TBM
40. *Persea americana*	Alpokat	√	√	√	√	TBM
XV. Leguminoceae						
41. *Crotalaria striata*	Kac.giring-giring	-	√	√	√	BST
42. *Leucaena glauca*	Petai cina	-	√	-	√	BST
43. *Mimosa invisa*	Putri malu	-	-	-	√	BST
45. *Mimosa pigra*	Putri malu	-	-	-	√	BST
46. *Mimosa pudica*	Putri malu	-	-	-	√	BST
47. *Phithocellobium lobatum*	Jengkol	√	-	√	√	TBM
48. *Perkia speciosa* Hassk	Petai	√	-	-	√	TBM
XVI. Loranthaceae						
47. *Loranthus europaeus*	Benalu	-	√	√	√	BST
XVII. Lythraceae						
48. *Cupea* sp.	-	-	√	√	√	BST
XVIII. Malvaceae						
49. *Sida rhombifolia*	Sidaguri		√	√	√	BST
50. *Urena lobata*	Pulut-pulut	-	√	√	√	BST
XIX. Melastomataceae						
51. *Melastoma polianthum*	Sikaduduk	-	√	√	√	BST
XX. Meliaceae						
52. *Lansium domesticum*	Duku	√	-	√	√	TBM
XXI. Musaceae						
53. *Musa paradisiaca*	Pisang	√	-	√	√	TMT
XXII. Myrtaceae						
54. *Syzygium aqueum*	Jambu air	√	-	√	√	TBM
55. *Syzygium jambos*	Jambak	√	-	√	√	TBM
56. *Psidium guajava*	Jambu biji	√	-	√	√	TMT

Family/species		Plant Status		Type of food		Flowering time
Scientific	Local name	Cultivated	Wild	Nectar	Pollen	
1	**2**	**3**	**4**	**5**	**6**	**8**
XXIII. Rutaceae						
57. *Cytrus aurantifolia*	Jeruk nipis	√	-	√	√	TBM
58. *Cytrusmaxima* Merr	Jeruk bali	√	-	√	√	TBM
59. Cytrus sinensis	Jeruk manis	√	-	√	√	TBM
XXIV. Sapindaceae						
60. *Nephelium lappaceum*	Rambutan	√	-	√	√	TBM
61. *Theobroma cacao*	Coklat *	√	-	√	√	BST
XXV. Tiliaceae						
62. *Munotingia calabura*	Seri	-	√	√	√	BST
XXVI. Verbenaceae						
63. *Stachytarpheta indica*	Bujang kalam	-	√	√	√	BST
64. *Stachytarpheta jamaicensis*	Bujang kalam	-	√	√	√	BST
65. *Tectona grandis*	Jati	√	-	√	√	TBM
65. *Peronema canescens* Jack	Sunkai	√	-	√	√	TBM
Total		30	35	52	**52**	

*****= primary cultivated plant, TBM= seasonal flowering plant, BST= perennial flowering plant, TMT= flowering plant depending on the growing season

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