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Diversity and blooming season of food sources plant of *Apis cerana* (Hymenoptera: Apidae) in polyculture plantation in West Sumatra, Indonesia

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Abstract. *Jasmi. 2017. Diversity and blooming season of food sources plant of Apis cerana (Hymenoptera: Apidae) in polyculture plantation in West Sumatra, Indonesia. Biodiversitas 18: 34-40.* The existence of honeybees in a habitat was highly affected by the presence of food source plant. Therefore, the research was conducted to examine the diversity and the blooming season of food source plant of *Apis cerana* Fabr. in polyculture plantation in West Sumatra from March 2011 to March 2012. Samples were collected with a plot method of 100 m x 100 m on altitudes of <100 m and >1.000 m asl. The results showed that 94 species (34 families) of food source plants for *A. cerana* were found. The most found species were Asteraceae (12 species) and Leguminoceae family (10 species). On the plateau, food source plants were 21 species, while on lowland there were 18 species and on both altitudes, there were 55 species (similarity index 75.34%). The number of cultivated plants was 46 species and the number of wild plants was 48 species. The cultivated plants in lowland were 34 species and 33 species in the plateau (similarity index 59.70%). Plants that bloom all year round were 59 species, plants that bloom depending on growing season were 15 species and annual plants that bloom annually were 20 species. The largest number of flowering plants was found in August with 88 species out of 94 species found.

Keywords: *Apis cerana*, blooming season, diversity, food source plant, polyculture plantation

INTRODUCTION

Honeybees (*Apis cerana* Fabr.) are widespread in Indonesia. The existence of these bees has been reported in Sumatra, Java, Bali, Kalimantan, Sulawesi, and Irian Jaya (Radloff et al. 2010). In West Sumatra, the average colonies population density on polyculture lowland planting area reached 4.8 colonies per hectare and 4.2 colonies per hectare on the plateau (Jasmi et al. 2014a). The bees have been used as pollinators on coffee plantations (Vergara and Badano 2008; Saepudin et al. 2011), even reproduction of queen bee has been done with grafting techniques (Kuntadi 2013).

Polyculture cropping is a unique ecosystem with a high value of economic, biodiversity and conservation. On the plantation, there are various species of crops and wild plants. The extent of polyculture cultivation in West Sumatra is in the third rank (5.93%) of the total land area according to the type of land use. Various of plants found in the area are industrial plants, forestry, and fruit plants (BPS 2011). Plantation plays an important role as habitat for various species of bees in Sweden, Poland, United Kingdom, Germany and Francis (Westphal et al. 2008) and as the provider of nesting cavity sites for *A. cerana* in West Sumatra (Jasmi et al. 2014b) and other various species of bees lodged in a cavity in the Annapolis valley, Nova Scotia, Canada (Sheffield et al. 2008). Another important role of the plantation is food resources provider for *A. cerana* in Kepahiang Sub-district of Bengkulu (Saefudin et al. 2011), for *A. mellifera* in Veracruz, Mexico (Vergara and Badano 2008), in Zaria, Nigeria (Mbah and Amao 2010), in Ndokwa, Niger Delta, Nigeria (Emuh and Ofuoku 2012) and for wild bees in Ottawa, Allegan and Van Buren, North America (Tuell et al. 2009).

From the aspect of mutuality, plantation plays an important role as a provider of food resources, while honey bees act as agents of pollinator. The plantation has a relatively high diversity of plant species which can be used as a source of pollen and nectar for honey bees. Each type of honey bees use different number of species of food source plants in different locations, such as *A. mellifera* honeybee which uses 18 species in Zaria, Nigeria (Mbah and Amao 2010), and 26 species in Iseyin and Ilesa of Southeast Nigeria (Ayansola and Davies 2012), while *A. dorsata* uses 194 species in Garhwal Himalaya India (Tiwari et al. 2010), and stingless bee *Melipona rufiventris* Lepeletier uses 57 species in Ubatuba, São Paulo State, Brazil (Fidalgo and Kleinert 2010), but up to now, there are no reliable data and information about the species and the flowering period of plants in polyculture plantation which are used as food source for *A. cerana* honeybees. This study aims to determine the species and flowering period of food source plants for *A. cerana* in polyculture planting area in West Sumatra, Indonesia. The diversity of plant species in polyculture plantation is important for conservation and cultivation of *A. cerana* honey bees.

MATERIALS AND METHODS

Area of study

The study was conducted in lowland and highland polyculture planting areas in West Sumatra, Indonesia from March 2011 to March 2012. The lowland (altitude: <100 m above sea level) is located in Nagari Sungai Buluh, Sub-district of Batang Anai and Parik Malintang, Sub-district of Enam Lingkung, Padang Pariaman, West Sumatra, Indonesia. The location has an average daily temperature of 29.7^{o}C, relative air humidity of 85.9%, and average annual rainfall of 368.4 mm with an average of rainy days as much as 19 days per month (BPS 2011). Polyculture plantation used as a research location (Figure 1.A-B) is dominated by coconut trees (*Cocos nucifera*), cocoa (*Theobroma cacao*) and fruit trees, such as durian (*Durio zibethinus*), kedondong (*Spondias pinnata*), and rambutan (*Nephelium lappaceum*).

The highland (altitude: > 1000 m above sea level) is located in Nagari Andaleh, Batipuh Subdistrict, Tanah Datar, West Sumatra. The location has an average daily temperature of about 26° C and monthly rainfall of 549.00 mm per month (BPS 2011). Polyculture plantation used as a research location (Figure 1c-d) is dominated by coffee (*Coffea canephora*), cinnamon (*Cinnamomum burmanii*) and dadap (*Erythria variegata*), while on the edges, various species of trees are planted. Wild plants commonly found in the planting area are lakek kanji (*Bidens pilosa*) and Tansi grass (*Galinsoga parviflora*).

Method

The research was conducted by survey method namely by observing the species of flowering plants visited by *A. cerana* worker bees in polyculture plantation area. Observations were carried out visually, and a binocular was used to observe the relatively high plants. Bees have taken pollen were identified by the visibility of collected pollen on its corbicula, at the time of taking nectar, bees stuck its proboscis on the basis of the flower. To determine the observation area, the model from Steffan-Dewenter and Kuhn (2003) is modified and used. The observation was carried out on a sample plot measuring 100 m x 100 m. The number of sample plots used at each height was five sample plots.

The blooming period was set when plants were flowering at the time of observation. Plant species found in flowering condition were recorded and the numbers of visiting of worker bees were counted. Observations were made only once a month from 7: 00 to 10: 00 am and at 02: 00 to 05: 00 pm at each point of observation. On the visited plants, some of its parts, such as branches, leaves, flowers and fruits, were collected and stored in a plastic bag and labeled. In order to make herbarium, the plant was pressed with suppressant board (45 cm x 30 cm) and newspaper paper measuring 44 cm x 28 cm (Womersley 1981). The identification of plant referred to Backer and Bakhuizen van den Brink (1964-1968) and Lawrence (1951) and was carried out at the Laboratory of Plant Taxonomy,

Figure 1. Research location in polyculture plantation in West Sumatra. A-B. Lowlands polyculture plantation. A. Polyculture plantation area of coconut, durian, and kedondong, B. Polyculture plantation area of areca nut, cocoa, and coconut. C-D. Highlands polyculture plantation, C. Coffee plantation area intercropped with various tree species, D. Coffee plantation area intercropped with cinnamon

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Food source plant species are grouped on the basis of the blooming time, namely all year round flowering plants (BST, flowers appear all the time in a year), season flowering plants (TBM, flowers appear only at a certain time/season in a year), and annual plants (TMT, flowers appear only one time of planting). The flowering period is associated with the emerging time of flower until the end of its emerging on a certain plant species and is expressed in units of months. The visit frequency of *A. cerana* worker bee on any flowering plants during the observations are grouped into three categories (Ayansola and Davies 2012), namely: (1) frequent category (+++), i.e. if the worker bees are found to visit the same flower for more than nine times, (2) moderate category (++), i.e. if the worker bees are found to visit the same flower for 5-8 times, and (3) rare category (+), i.e. if the worker bees are found to visit the same flower for less than four times.

RESULTS AND DISCUSSION

Food source plants for *A. cerana* in polyculture plantation area in West Sumatra consist of 94 species and are included in 34 families. The family having the highest number of species are Asteraceae (12 species) and Leguminoceae (10 species). The number of plants is 21 species found in the highlands, and 18 species in the lowlands, and 55 species in both heights (species total similarity index 75.34%).

Food source plants for bees include 48 species of cultivated plants and 46 species of wild plants. The number of cultivated plants is 12 species in the highland, about 13 species in the lowlands, and 23 species on both heights (similarity index 59.70%). The cultivated plants consist of 18 species of fruit plants, 11 species of vegetable plants, 9 species of plantation plants, 6 species of forestry plants and 2 species of food crops. Lowland crops are dominated by fruit plants (18 species) and industry plants (6 species) while highlands are dominated by forestry plants (5 species). The number of wild plants is 9 species in the highlands, only 5 species in the lowlands, and 32 species on both heights.

The visiting frequency of worker bees on plants is as follows, six species are on frequent category, 41 species are on moderate category, and 47 species are in the rare category. Cultivation plants belonging to frequent category consist of two species, namely *Cocos nucifera* and *Areca catechu*. While on wild plants, it consists of four species, namely *Asystasia coromandeliana, Bidens pilosa, Galinsoga parviflora,* and *Mimosa pudica*. On highlands, plants with the frequent category are two species, namely *B. pilosa* and *G. parviflora*. There is species of *C. nucifera* on lowlands, and, there are three species on both heights, namely *A. catechu, A. coromandeliana,* and *M. pudica*. Those six plant species can bloom all year round.

Food source plants blooming all year round are 64 species, and 14 species are the plants that bloom depending on the season, and 28 species of annual plants. Most plants blooms in August to December, namely 85-87 of 94 food sources species. Cultivated plants mostly bloom in October to December. There are 12 species of food resources cultivated plants in the highlands and they can bloom in December. 11 out of 13 cultivated plants species in lowland blooms in December, while on both altitude, 22 species blooms in October (Table 1).

The species of food resource plants that support the existence of *A. cerana* colonies in polyculture plantation area in West Sumatra is 94 species (34 families). The plant species and a number of visits depend on the diversity and flowering time of plants at a site. This can be seen from the data that 94 plant species were visited by *A. cerana* in polyculture plantation area in West Sumatra, 70 species were visited by *Apis mellifera* in Isfahan, Iran (Amiri and Shariff 2014) and 194 plant species were visited by *A. dorsata* in Garhwal Himalaya, India (Tiwari 2010), and from these locations, there are only 19 same species. This suggests that differences in location can cause different varieties of plants. This is made clear by Yonega and Gupta (2012) that, nowadays, it has been recorded that about 1,200 Angiospermae plant species have been visited by various types of Apis worker bees around the world.

The factor of the habit in choosing the crop type also affects the diversity of plant species in polyculture planting area. This study finds 48 species of cultivation plants, while the number of plant species which are intensively cultivated by society in various areas in West Sumatra are 51 species and belong to the group of food, vegetables, fruit and industry crops. The crops are grown in various location and altitude (BPS 2011). Various species of crops have been exploited by *A. cerana* honeybee as a source of nectar and pollen in Coorg Karnataka, India (Shubharani et al. 2012).

Eight out of 11 vegetable crops as the food source of *A. cerana* are found in the highlands. The vegetables are planted as intercrops on the edge and the middle of the garden. Locations having a direct border with the gardens are also commonly planted by various kinds of vegetables. Referring to Nicholls and Altieri (2012), in the field of agricultural intensification, the edges of fields, road edges, headlands, guardrail, and the gardens which are cultivated around the farms play an important role in the protection of pollinators insect. Maintenance and restoration of hedgerows and the main vegetation play an important role in the protection of pollinators.

The species of food sources plant of *A. cerana* are dominated by the family of Asteraceae (12 species) and Leguminoceae (10 species) and are distributed on both altitudes. Referring to Lawrence (1951), the family of Asteraceae and Leguminoceae has relatively high species and are distributed on the lowlands to the highlands. Plant habitus that belongs to the family of Asteraceae is terna, small shrubs, and is rarely in the form of woody trees. Habitus of Leguminoceae is Terna, bushes, shrubs, and trees. Asteraceae has members of about 20,000 species (950 genera), while Leguminoceae consists of 13,000 species (550 genera) which is distributed in various countries.

Table 1. Family and species, distribution and status, flowering time and the visit frequency of *A. cerana* worker bees on food resource plants in polyculture planting area of West Sumatra, Indonesia

Family / Species	Distribution		Status		Flowering time		Visit frequency	Reference
	<500	>600	B	Tl	Season	Period		
Acanthaceae								
1. *Asystasia coromandeliana* Bl.	+	+	-	+	BST	Jan-Dec	+++	Es
Anacardiaceae								
2. *Mangifera indica* L.	+	+	+	-	TBM	Jun-Dec	++	Ti
3. *Mangifera* sp.1	+	+	+	-	TBM	Jun-Dec	++	
4. *Mangifera* sp.2	+	+	+	-	TBM	Jun-Dec	++	
5. *Mangifera* sp.3	+	-	+	-	TBM	Jun-Dec	++	
6. *Spondias pinnata* Kurz.	+	-	+	-	TBM	Apr-May	+	Ti
Arecaceae								
7. *Areca catechu* L.	+	+	+	-	BST	Jan-Dec	+++	
8. *Arenga pinnata* Merr.	-	+	-	+	BST	Jan-Dec	++	
9. *Caryota mitis* Lour.	-	+	-	+	BST	Jan-Dec	++	
10. *Cocos nucifera* L.	+	-	+	-	BST	Jan-Dec	+++	
Asteraceae								
11. *Ageratum conyzoides* L.	+	+	-	+	BST	Jan-Dec	+	Ti
12. *Ageratum hostonianum* Mill.	+	+	-	+	BST	Jan-Dec	+	
13. *Bidens pilosa* L.	-	+	-	+	BST	Jan-Dec	+++	Pe, Ti
14. *Clibadium surinamens* L.	+	+	-	+	BST	Jan-Dec	++	
15. *Eupatorium inulifolium* L.	+	+	-	+	BST	Jan-Dec	++	
16. *Eupatorium odoratum* L.	+	+	-	+	BST	Jan-Dec	++	
17. *Galinsoga parviflora* Cav.	-	+	-	+	BST	Jan-Dec	+++	
18. *Tithonia diversifolia* Gray.	-	+	-	+	BST	Jan-Dec	++	
19. *Mikania micrantha* Willd.	+	+	-	+	BST	Jan-Dec	++	
20. *Siplanthes iabadicensis* A. H. Moore.	+	+	-	+	BST	Jan-Dec	++	
21. *Siplanthes paniculata* Wall. Ex DC.	+	+	-	+	BST	Jan-Dec	++	
22. *Tridax procumbens* L.	+	+	-	+	BST	Jan-Dec	+	Ti
Bombacaceae								
23. *Durio zibethinus* Murr.	+	+	+	-	TBM	Jun-Dec	++	
Brassicaceae								
24. *Brassica rapa* L.	-	+	+	-	TMT	Jan-Dec	++	T, Ti
25. *Brassica* sp.	-	+	+	-	TMT	Jan-Dec	++	
26. *Rorippa indica* (L) Hiern.	+	+	+	+	BST	Jan-Dec	++	
Caesalpiniaceae								
27. *Erythria variegata* L.	-	+	+	+	TBM	Nov-Dec	+	
Caricaceae								
28. *Carica papaya* L.	+	+	+	-	TMT	Jan-Dec	++	
Capparidaceae								
29.*Cleome rutidosperma* DC.	+	-	-	+	BST	Jan-Dec	+	
30. *Cleome viscose* L.	+	+	-	+	BST	Jan-Dec	+	
Convolvulaceae								
31. *Calystegia sapium*	+	-	-	+	BST	Jan-Dec	+	
32. *Ipomoea triloba* L.	+	-	-	+	BST	Jan-Dec	+	
Cucurbitaceae								
33. *Citrulus vulgaris* L.	+	-	+	-	TMT	Jan-Dec	+	
34. *Momordica charantia* L.	+	+	+	-	TMT	Jan-Dec	++	Ti
35. *Cucumis sativus* L.	+	-	+	-	TMT	Jan-Dec	++	Ti
36. *Sechium edule* (Jacq.) Swartz.	-	+	+	-	TMT	Jan-Dec	++	
Cyperaceae								
37. *Cyperus brevifolius* Hassk.	+	+	-	+	BST	Jan-Dec	+	
38. *Cyperus kylingia* Endl.	+	+	-	+	BST	Jan-Dec	++	
Euphorbiaceae								
39. *Aleurites moluccana* (L.) Willd.	+	+	+	-	TBM	Sep-Oct	++	
40. *Hevea brasiliensis* (Willd. ex A. Juss.) M. A.	+	-	+	-	TBM	Jun-Dec	+	
41. *Omalanthus pupulneus* (Geisl) Pax.	-	+	-	+	BST	Jan-Dec	++	
Graminae								
42. *Oryza sativa* L.	+	+	+	-	TMT	Jan-Dec	++	
43. *Zea mays* L.	+	+	+	-	TMT	Jan-Dec	++	Ti
44. *Leersea hexandra* Swartz.	+	+	-	+	BST	Jan-Dec	+	
45. *Cynodon dactylon* (L.) Pers.	-	+	-	+	BST	Jan-Dec	+	
46. *Echinochloa colanum* L.	+	+	-	+	BST	Jan-Dec	+	
Labiatae								
47. *Hyptis brevipes* Poit.	+	+	-	+	BST	Jan-Dec	+	

48. *Hyptis capitata* Auct. non Jacq.	+	+	-	+	BST	Jan-Dec	+	
49. *Leucas lavandula* Smith.	+	-	-	+	BST	Jan-Dec	+	
Lauraceae								
50. *Cinnamomum burmanii* Nees ex Bl.	+	+	+	-	TBM	Oct-Feb	++	
51. *Persea Americana* Mill.	+	+	+	-	TBM	Oct-Feb	++	
Loranthaceae								
52. *Loranthus europaeus* Jacq.	+	+	-	+	BST	Jan-Dec	++	
Leguminoceae								
53. *Acacia auriculiformis* A. Cunn. Ex Bth	+	-	+	-	BST	Jan-Dec	++	Ti
54. *Crotalaria striata* DC.	+	+	-	+	BST	Jan-Dec	+	
55. *Leucaena glauca* Auct. non Bth.	+	+	-	+	BST	Jan-Dec	++	
56. *Mimosa invisa* Mart. ex Colla.	+	+	-	+	BST	Jan-Dec	++	
57. *Mimosa pigra* L.	+	+	-	+	BST	Jan-Dec	++	
58. *Mimosa pudica* L.	+	+	-	+	BST	Jan-Dec	+++	
59. *Phaseolus* sp.1	+	+	+	-	TMT	Jan-Dec	+	
60. *Phaseolus* sp.2	-	+	+	-	TMT	Jan-Dec	+	
61. *Pithecellobium lobatum* Bth.	+	-	+	-	TBM	Nov-Jan	++	Le
62. *Perkia speciosa* Hassk.	+	-	+	-	TBM	Sep-Dec	++	
Lythraceae								
63. *Cupea* sp.	+	+	+	-	BST	Jan-Dec	++	
Malvaceae								
64. *Sida rhombifolia* L.	+	+	-	+	BST	Jan-Dec	+	Ti
65. *Urena lobate* L.	+	+	-	+	BST	Jan-Dec	+	Ti
Melastomataceae								
66. *Melastoma polianthum* Bl.	+	+	-	+	BST	Jan-Dec	+	
Meliaceae								
67. *Lansium domesticum* Corr.	+	-	+	-	TBM	Dec-Feb	+	
68. *Melia azedarach* L.	-	+	+	-	TBM	Dec-Feb	++	Ti
69. *Toona sureni* (Bl.) Merr.	-	+	+	-	TBM	Oct-Jan	++	Ti
Musaceae								
70. *Musa paradisiaca* L.	+	+	+	-	TMT	Jan-Dec	+	Ti
Myrtaceae								
71. *Syzygium aqueum* (Burm. f.) Alst.	+	+	+	-	TBM	Jun-Dec	+	
72. *Syzygium jambos* (L.) Alst.	+	-	+	-	TBM	Jun-Nov	+	
73. *Psidium guajava* L.	+	+	+	-	TMT	Jan-Dec	++	Ti
Passifloraceae								
74. *Passiflora foetida* L.	+	+	-	+	BST	Jan-Dec	+	
Rubiaceae								
75. *Coffea canephora* Pierrre ex Froehner	-	+	+	-	TBM	Jul-Dec	+	
76. *Coffea Arabica* L.	-	+	+	-	TBM	Jun-Dec	+	
77. *Borreria leavis* (Lamk) Griseb.	+	+	-	+	BST	Jan-Dec	+	
Rutaceae								
78. *Citrus aurantifolia* (Christm. & Panz.)	+	+	+	-	TBM	Jun-Oct	+	Ti
79. *Citrus maxima* (Burm. f.)	+	-	+	-	TBM	Sep-Dec	+	
80. *Citrus sinensis* (L.) Osbeck.	+	+	+	-	TBM	Oct-Dec	+	Ti
Sapindaceae								
81. *Nephelium lappaceum* L.	+	+	+	-	TBM	Jul-Oct	+	
Solanaceae								
82. *Physalis angulata* L.	+	+	-	+	BST	Jan-Dec	+	
83. *Solanum turvum* Swartz.	+	+	-	+	BST	Jan-Dec	+	Rj
84. *Solanum melongena* L.	-	+	+	-	TMT	Jan-Dec	+	
85. *Capsicum annuum* L.	-	+	+	-	TMT	Jan-Dec	+	Ti
Sterculiaceae								
86. *Pterosperma blumeanum* Hochr.	-	+	+	-	TBM	Aug-Dec	+	
87. *Theobroma cacao* L.	+	+	+	-	BST	Jan-Dec	+	
Tiliaceae								
88. *Muntingia calabura* L.	+	-	-	+	BST	Jan-Dec	+	
Umbelliferae								
89. *Eryngium foetidum* L.	-	+	-	+	BST	Jan-Dec	+	
Urticaceae								
90. *Toxicodendron radicans* (L.) Kuntze	-	+	-	+	BST	Jan-Dec	+	
Verbenaceae								
91. *Stachytarpheta indica* (L.) Vahl.	+	+	-	+	BST	Jan-Dec	+	
92. *Stachytarpheta jamaicensis* (L.) Vahl.	+	+	-	+	BST	Jan-Dec	+	
93. *Tectona grandis* L. f.	+	-	+	-	TBM	Jun-Sep	++	Ti
94. *Peronema canescens* Jack.	+	+	+	-	TBM	Sep-Jan	+	
Total	76	70	48	46				

Note: + = present,-= Absent, B = cultivated plants, Tl = wild plants, BST = to bloom all year round, TBM = annuals plants, TMT = to bloom depending on the growing season, Jan. = January, Feb. = February, Apr = April, May = May, June = June, July = July, Aug = August, Sept = September, Oct = October, Nov. = November, Dec = December, + = worker bees found to visit plants for less than four times during the observation, ++ = worker bees found to visit plants for 5-8 times during the observation, +++ = worker bees found to visit plants for more than 9 times during the observation. Es= Essandoh et al. (2011), Pe= Petrova et al. (2013), Rj = Raju et al. (2006), Ti = Tiwari et al. (2010)

Crop blooming all year round and frequently visited by *A. cerana* consists of two species, namely *C. nucifera* and *A. catechu*. Coconut (*C. nucifera*) and Areca nut (*A. catechu*) belong to a group of industrial plants and are cultivated on a large scale and is one of the high commodities for local people. The planting area of these two commodities continues to increase from time to time, accompanied by an increase in average production per year. Areca nut is an exported commodity for Padang Pariaman District. And, coconut plantation in this district is the largest plantation in West Sumatra with 33,940.46 hectares. The location spreads from city areas to village areas (BPS 2011). Coconut plant is also considered as a pollen source for *A. cerana* in the district of Coorg, Karnataka, India (Shubharani et al. 2012).

The main feed source crops for *A. cerana* on highland polyculture plantation consist of two species, namely *Coffee arabica* and *Coffee canephora*. Both species of coffee plants produce relatively high amounts of flowers in one flowering period. The flowers are white. Saepudin et al. (2011) reported that the nectar production of these coffee plants is about 0.64 mL per 25 buds per day, equivalent to 18.14 mL/tree/day. The nectar production on these coffee plants fluctuates and the highest average of nectar production occurred in July.

Wild plants as a source of feed for *A. cerana* in polyculture planting area in West Sumatra are 46 species. The relatively same wild plant species are also visited by other pollinating insects, for example, 43 species of 22 families of wild plants in an area of Malang and Pasuruan (East Java) are visited by various pollinating insects (Erniwati and Kahono 2009). Pollinating insects are attracted by the flowers of wild plants, mainly due to the substances excreted by these flowers in the form of pollen and nectar. Some families of plants are very important as a source of pollen for honeybees. The availability of these plants as a source of pollen varies from time to time (Fidalgo and Kleinert 2010). Annual and perennial plants that exist in and around the farm location became a source of nectar and pollen containing important components as food for many insects (Ratnadass et al. 2012).

All year round blooming wild plants spreading on both altitude and as the food source for *A. cerana* with the high category are four species, namely *A. coromandeliana*, *B. pilosa*, *G. parviflora*, and *M. pudica*. Of the four species of these plants, *A. coromandeliana* has been reported as dominant weeds in oil palm plantations in South Assin, Ghana (Essandoh et al. 2011), *M. pudica* grows wild in the mangrove areas and is used as a food source for *A. cerana* in Qingland, Hainan Island, China (Yao et al. 2006) and in the North Queensland (Hyatt 2012). *G. parviflora* is widespread in Asia, Africa and in other parts of the world at lowland to the area with an altitude of over 1000 m. This plant is the weeds on various crops (Petrova et al. 2013). *B. pilosa*, including perennial herb, is widely distributed in tropical and temperate location (Petrova et al. 2013) and is the food source for *A. dorsata* in Garhwal, Himalaya, India (Tiwari et al. 2010), but to be a food source for *A. cerana* has never been reported.

Six plant species (2 species of cultivated plants and 4 species of wild plants) are frequently visited by bees, that it is categorized as frequent (+++) (Table 1). The visit frequency of honeybees is more in the crops with many flowers (Rollin et al. 2013). The foraging activity of bees has so many relations to the natural plant communities and the climate. Some factors affecting the nectar concentration collected by bees are the distance of flowers to the nest, the availability and the morphology of flower (Fidalgo and Kleinert 2010).

Species of food sources plant for *A. cerana* in polyculture planting area has a various flowering season. The difference in the flowering season plays an important role in maintaining the continuous availability of food resources for bees. Planting area with a high diversity of plant species provides abundant sources of pollen and nectar throughout the year. Referring to Winfree et al. (2008), a high number of visiting species is due to the abundant amount of flowers, the variety of flower colors, and the attractiveness of plants. The density and diversity of flowers are the most important and determining factor for the diversity of pollinating insects, especially when the flowers are available throughout the year. Taha and Bayoumi (2009) reported that the frequency of bee visits in plants is positively related to the flowering time of plants. Bees will more intensively visit the plant in peak flowering time.

Total similarity index of food resources plants for *A. cerana* in lowland (<100 m asl) and highland (> 1,000 m asl) polyculture planting area is 75.34% or 80 plant species. The similarity percentage of food source species in the two altitudes relates to spreading regions of plant species. Various plant species are widespread and can thrive in a variety of ecosystems. Man-modified habitat is ecologically the homogeneity that is rich with biodiversity (Petrova et al. 2013). Human has a powerful influence in modifying the landscape through fragmentation, degradation, and destruction of natural habitats and in the creation of new anthropogenic habitats (Winfree et al. 2009).

Polyculture cultivation in West Sumatra can provide food source plants for *A. cerana* honey bees throughout the year. Polyculture cultivation is supported by 94 species (34

families) consisting of 48 species of crop and 46 species of wild plants. The details are more than 68% of plant species blooming all year round, 21.87% of plants blooming depending on the flowering season, and 29.78% of annuals plants. The average number of species to flower monthly is 73.75% (70 species) with peak flowering season in August-December with more than 91% of species producing flowers. From these findings, it can be recommended that the cropping polyculture in West Sumatra can be used as a location for honeybee cultivation or other wild bee conservation.

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REFERENCES

Amiri F, Shariff ARM. 2014. Multivariate and an ordination approach to classify the attractiveness of the plant species in Pastoral Lands. Pertanika J Trop Agric Sci 37 (3): 347-362

Ayansola AA, Davies BA. 2012. Honeybee floral resources in Southwestern Nigeria. J Biol Life Sci 1 (3): 127-139.

Backer CA, Bakhuizen van den Brink Jr. RC. 1964-1968. Flora of Java (Spermatophytes Only) Vol. I-III: Gymnospermae, Families 1-7 Angiospermae, Families 8-110. Wolters-Noordhoff, Groningen, Netherland.

BPS [Badan Pusat Statistik]. 2011. Statistics of West Sumatra in 2010. The Central Statistics Agency of West Sumatra Province, Padang. [Indonesia]

Essandoh PK, Armah FA, Odoi JO, Yawson DO and Afrifa EKA. 2011. Floristic composition and abundance of weeds in an oil palm plantation in Ghana. ARPN J Agric Biol Sci 6 (1): 20-31.

Erniwati, Kahono S. 2009. The role of wild plants in the conservation of pollinating insect order Hymenoptera. J Teknik Lingkungan 10 (2): 195-203. [Indonesia]

Fidalgo AO, Kleinert AMP. 2010. Floral preferences and climate influence in nectar and pollen foraging by *Melipona rufiventris* Lepeletier (Hymenoptera: Meliponini) in Ubatuba, São Paulo State, Brazil. Neotrop Entomol 39 (6): 879-884.

Hyatt S. 2012. Asian honey bee (*Apis cerana javana*) in Cairns, Far North Queensland foraging, nesting and swarming behaviour. Report of Field Observations April 2007-September 2011. Department of Agriculture, Fisheries and Forestry, State of Queensland, Australia.

Jasmi, Salmah S, Dahelmi et al. 2014a. The fluctuation of colony population *Apis cerana* Fabr. (Hymenoptera: Apidae) in polyculture plantations in West Sumatra. Int J Sci Res 3 (3): 849-855.

Jasmi, Salmah S, Dahelmi et al. 2014b. Nesting site *Apis cerana* Fabr. (Hymenoptera: Apidae) in two different altitude of polyculture plantations in West Sumatra. Hayati J Biosci 21 (3): 135-143.

Kuntadi. 2013. The influence of larvae age on the quality of queen produced in the queen bees *Apis cerana* L. (Hymenoptera: Apidae) breeding with a transplant technique. J Entomol Indonesia 10 (1): 1-6. [Indonesian]

Lawrence GHM. 1951. Taxonomy of Vascular Plants. The Macmillan Company, New York.

Mbah CE, Amao AO. 2010. Natural foods and feeding habits of the African honey bee *Apis mellifera adansonii* Latrielle (1804) in Zaria, Northern Nigeria. Apidologie 41: 264-277.

Nicholls CI, Altieri MA. 2012. A review: Plant biodiversity enhances bees and other insect pollinators in agroecosystems. Agron Sustain Dev 33: 257-274.

Petrova A, Vladimirov V, Georgiev V. 2013. Invasive Alien Species of Vascular Plants in Bulgaria. Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Science, Sofia.

Radloff SE, Hepburn C, Hepburn HR et al. 2010. Population structure and classification of *Apis cerana*. Apidologie 41: 589-601.

Ratnadass A, Fernandes P, Avelino J, Habib R. 2012. Plant species diversity for sustainable management of crop pests and diseases in agroecosystems: a review. Agronomy for Sustainable Development, Springer Verlag/EDP Sciences/INRA (1): 273-303

Rollin O, Bretagnolle V, Decourtye A, Aptel J, Michel N, Vaissière BE, Henry M. 2013. Differences of floral resource use between honey bees and wild bees in an intensive farming system. Agric, Ecol Environ 179: 78-86.

Saepudin R, Fuah AM, Sumantri C et al. 2011. Increased productivity of honeybee through the application integration with coffee plantations. Jurnal Ilmu-Ilmu Peternakan 21: 29-39. [Indonesian]

Shubharani R, Sivaram V, Roopa P. 2012. Assessment of honey plant resources through pollen analysis in Coorg Honeys of Karnataka State. Intl J Plant Repro Biol 4 (1): 31-39.

Sheffield CS, Kevan PG, Westby SM, Smith RF. 2008. Diversity of cavity-nesting bees (Hymenoptera: Apoidea) within apple orchards and wild habitats in the Annapolis Valley, Nova Scotia, Canada. Can Entomol 140 (2): 235-249.

Steffan-Dewenter I, Kuhn A. 2003. Honeybee foraging in differentially structured landscapes. Proc R Soc London Ser B: Biol Sci 270: 569-657.

Taha EA, Bayoumi YA. 2009. The value of honey bees (*Apis mellifera* L.) as pollinators of summer seed watermelon (*Citrullus lanatus colothynthoides* L.) in Egypt. Acta Biologica Szegediensis 53 (1): 33-37.

Tiwari P, Tiwari JK, Ballabha R. 2010. Studies on sources of bee-forage for rock bee (*Apis dorsata* F.) from Garhwal Himalaya, India: A Melissopalynogaical Approach. Nat Sci 8 (6): 5-15.

Tuell J K, Ascher J S, R. 2009. Wild bees (Hymenoptera: Apoidea: Anthophila) of the Michigan highbush blueberry agroecosystem. Ann Entomol Soc Am 102 (2): 275-287.

Vergara CH, Badano EI. 2008. Pollinator diversity increases fruit production in Mexican coffee plantations: The importance of rustic management systems. Agric Ecosyst and Environ 30: 1-7.

Westphal C, Bommarco R, Carre´ G, Lamborn E, Morison N, Petanidou T, Potts SG, Roberts SPM, Rgyi HS, Tscheulin T, Vaissiere BE, Woyciechowski M, Biesmeijer JC, Kunin WE, Settele J, Steffan-Dewenter I. 2008. Measuring bee diversity in different european habitats and biogeographical regions. Ecol Monogr 78 (4): 653-671.

Winfree R, Williams NM, Caines H. 2008. Wild bee pollinators provide the majority of crop visitation a cross land-use gradients in New Jersey. J Appl Ecol 45: 793-802.

Winfree R, Aguilar R, Vazquez DP, Lebuhn G, Aizen MA. 2009. A meta-analysis of bees' responses to anthropogenic disturbance. Ecology 90 (8): 2068-2076.

Womersley JS. 1981. A Manual of Plant Collecting and Herbarium Development. Food and Agriculture Organization of the United Nations, Rome.

Yanega D, Gupta RK. 2012. Genus *Apis* Linnaeus. Jai Narain Vyas University, Jodhpur, India.

Yao Y, Bera S, Wang YF. 2006. Nectar and pollen sources for honeybee (*Apis cerana cerana* Fabr.) in Qinglan mangrove area, Hainan Island, China. J Integr Plant Biol 48 (11): 1266-1273.