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RESEARCH ARTICLE

The distribution and nest-site preference of *Apis dorsata binghami* at Maros Forest, South Sulawesi, Indonesia

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Abstract: The giant honey bee, *Apis dorsata binghami* is subspecies of *Apis dorsata*. This species of bee was only found in Sulawesi and its surrounding islands. This study is aimed to study the distribution and characteristics of nest and nesting trees, nesting behavior of *Apis dorsata binghami* in the forests of Maros, South Sulawesi, Indonesia. The distributions of nests were observed using a survey method to record the species and characteristics of nesting trees, as well as the conditions around the nest. Results showed that 102 nests (17 active nests, 85 abandoned combs) of *A. d. binghami* were found. We found 34 species belong to 27 genera in 17 families of plants as nesting sites of giant honey bee. The common tree species used as nesting sites were *Ficus subulata* (Moraceae), *Adenanthera* sp. (Fabaceae), *Spondias pinnata* (Anacardiaceae), *Artocarpus sericoarpus* (Moraceae), *Alstonia scholaris* (Apocynaceae), *Knema cinerea* (Myristicaceae), *Litsea mappacea* (Lauraceae), and *Palaquium obovatum* (Sapotaceae). The nests were found in 0-11 meters (11 nests), 11-20 meters (40 nests), and more than 21 meters (51 nests) from ground level. The nests of giant honey bee were found in sturdy and woody branches, hard to peel, the slope of the branches was <60°, and nests were protected by liane plants, foliage, or both them.

Key words: *Apis dorsata binghami*, giant honey bees, nesting tree, nest, South Sulawesi.

Introduction

The giant honey bee (*Apis dorsata)* is one of five species found in Indonesia. Those species are *A. andreniformis, A. dorsata, A. cerana. A. koschevnikovi,* and *A. nigrocincta* (Engel 2012). *Apis dorsata* is widely spread in Indonesia from Sumatera to Sulawesi, Timor

and surrounding small islands (Sakagami *et al*. 1980; Oldroyd *et al*. 2000; Hadisoesilo 2001; Hepburn & Radloff 2011).

Apis dorsata has a large body size (about 17 mm in length) (Hepburn & Radloff 2011; Seeley 1985). Their nest has a large size, reaching to 1 m^2, single comb, built in the open, and usually hung on the branches of a large tree (Hadisoesilo 2001; Bertoni 2013). In one tree, more than ten nests of *A. dorsata* can be found, and usually clustered in the nesting tree (Kahono *et al.* 1999; Hadisoesilo 2001; Hepburn & Radloff 2011; Mead 2013).

The giant honey bee is a major producer of honey in Indonesia that supports national economic sectors and contributes to the regeneration of forests and various crops through pollination services (Starr *et al*. 1987; Appanah 1993; Momose *et al*. 1998; Hadisoesilo & Kuntadi 2007; Itioka *et al*. 2001; Partap 2011). The forest may be especially reliant on animal pollinators, such as honey bee because they are needed for long distance movement of pollen among spatially separated conspecific trees that are often self-incompatible or dioecious (Bawa 1990; Corlett 2004; Suwannapong *et al*. 2011).

Apis dorsata has a repeatedly migratory behavior, goes and comes back in a nesting earlier, if environmental conditions are maintained and not changed for the worse. The bee colonies live in the nest utilize flowers around it in a certain time period, and then at other time periods to leaving the place to stay in nesting trees which have different spring from the previous one. *Apis dorsata* colonies migrate to locations with flowering season (Kahono *et al.* 1999; Woyke *et al*. 2012). The existence of bee colony in habitat is supported by the availability of food resources and nesting conditions. *A. dorsata* also utilizes wild plants and crops around the forest as their food source (Bawa 1990; Kahono *et al*. 1999; Sarwono 2001).

In Indonesia, the giant honey bee is grouped into two subspecies, namely *A. d. dorsata* inhabit in west area of Wallacea line including the islands of Nusa Tenggara and *A. d. binghami* that is only found in the Sulawesi and surrounding islands as endemic bees (Sakagami *et al*. 1980; Raffiudin & Crozier 2007; Hepburn & Radloff 2011; Lo *et al*. 2010). Morphologically, these two species can be distinguished by the color of the worker's abdomen. Abdomen color of *A. d. binghami* is black with white stripes, while the abdomen colour of *A. d. dorsata* is brownish with orange strip. Nesting behavior of *A. d. binghami* and *A. d. dorsata* is also different. In one tree, *A. d. binghami* generally only was found 2-3 colonies (maximum 10 colonies), while *A. d. dorsata* can be found teens or even hundreds colonies (Hadisoesilo 2001). Selection of nest site is very important because the wrong choice can increase the risk of predation, threat of bad weather and reproductive failure causing harm to colony of social insects, such as bee colonies (Franks *et al*. 2002; Neupane *et al*. 2013).

Research on the species of nest trees used by *A. d. dorsata*, geographical position, nesting behavior, conditions of biotic and physical around the tree nest has been done in several areas in Java (Kahono *et al*. 1999), but the biology study of *A. d. binghami* has not been done. The forest in Maros is one location as migration area of *A. d. binghami*. People around the forest used it as a source of natural honey, but the important knowledge about bee colonies and habitat condition is unknown. This research was aimed to study the characteristic of nesting trees, distribution of nesting trees, nesting behavior, biotic and physical condition of forests in Maros, South Sulawesi, Indonesia.

Material and methods

Study sites: Observation of giant honey bees was carried out from July to November 2015 in forest at Laiya and Cenrana Baru village, Cenrana district, Maros, South Sulawesi, Indonesia.

Observation of nest distribution and nesting trees: These studies used survey or cruising and interview method (Bookhout 1996; Tongco 2007) that explored the forest to find the *A. d. binghami* nest by following the path that has been known by the wild honey hunter (Thomas *et al*. 2009). Walking through the forest was performed starting from 7:00 am to 5:00 pm about 3 days every week. The live and abandoned combs found were then recorded and the information about the existence of the nests in that location was also collected (Neupane *et al*. 2013). The position of the tree or nesting site was measured by using GPS *Garmin map 62s.*

Identification of nesting trees: Trees used for nesting bees were recorded, i.e., local name, photograph, and some parts of the plant (leaves, flowers, and fruits) were taken for identification. Identification of plant specimens was carried out in the Herbarium Laboratory, Faculty of Forestry, University of Hasanuddin, Makassar based on the existing of herbarium collections. Some specimens were verified in the Herbarium museum, Botanical Bogoriense, Indonesian Institute of Scienses (LIPI), Bogor, West Java, Indonesia.

Measurement of nest-site characteristics and conditions around the nest: The characteristics of nest observed were height from ground level (m) by using hagameter, tree diameter (cm) by using diameter at breast high meter (DBH), characteristic, slope and direction of branching, as well as the protected and unprotected nest of honey bee by using binoculars and compass. The conditions around the nest observed were the type of habitat, water distance from the nest, and environmental parameters, i.e., relative humidity (%) and temperature (ºC) by using termohygrometer, wind speed (km/h) using anemometer, and light intensity (lux) by using lux meter. Monthly average data of rainfall, humidity, and wind speed were found from Meteorology, Climatology and Geophysics office, Makassar, South Sulawesi, Indonesia.

Data analysis: Nesting site preference of *A. d. binghami* was described by descriptive analysis. The distribution of nests was visualized using ArcGIS 10.2 program. (http://www.esri.com/landing pages/software/arcgis/arcgis-desktop-student-trial).

Results

Distribution of nesting site

We found 102 nests of *A. d. binghami* in Laiya and Cerana Baru village (75 nests in Laiya and 27 nests in Cenrana baru). There were 17 active nests and 85 abandoned combs. The nests were found in altitude interval 520-750 meter above sea level (asl).

The pattern of *A. d. binghami* nest distribution was irregular, clustered and spread in the forest areas (Fig. 1). The results of personal observation and interviews with surrounding community showed that the numbers of colonies of *A. d. binghami* are higher in April to August, when the rainfall was low (Fig. 2). Even some colonies will remained until many years if sufficient food supplied and unharvested by local communities.

Nest trees-species

We found 34 species belonging to 27 genera and 17 families of trees used as nesting site of *A. d. binghami*. The common tree species used as nesting site of *A. d. binghami* were *Ficus subulata* (Fam. Moraceae), *Adenanthera* sp. (Fam. Fabaceae) and *Spondias pinnata* (Fam. Anacardiaceae), *Artocarpus sericocarpus* (Fam. Moraceae), *Alstonia scholaris* (Fam. Moraceae), *Knema cinerea* (Fam. Myristicaceae), *Litsea mappacea* (Fam. Lauraceae), and *Palaquium obovatum* (Fam. Sapotaceae). Based on observations and interviews with honey hunter in the forest, *A. d. binghami* colony did not choose to seek nesting tree species.

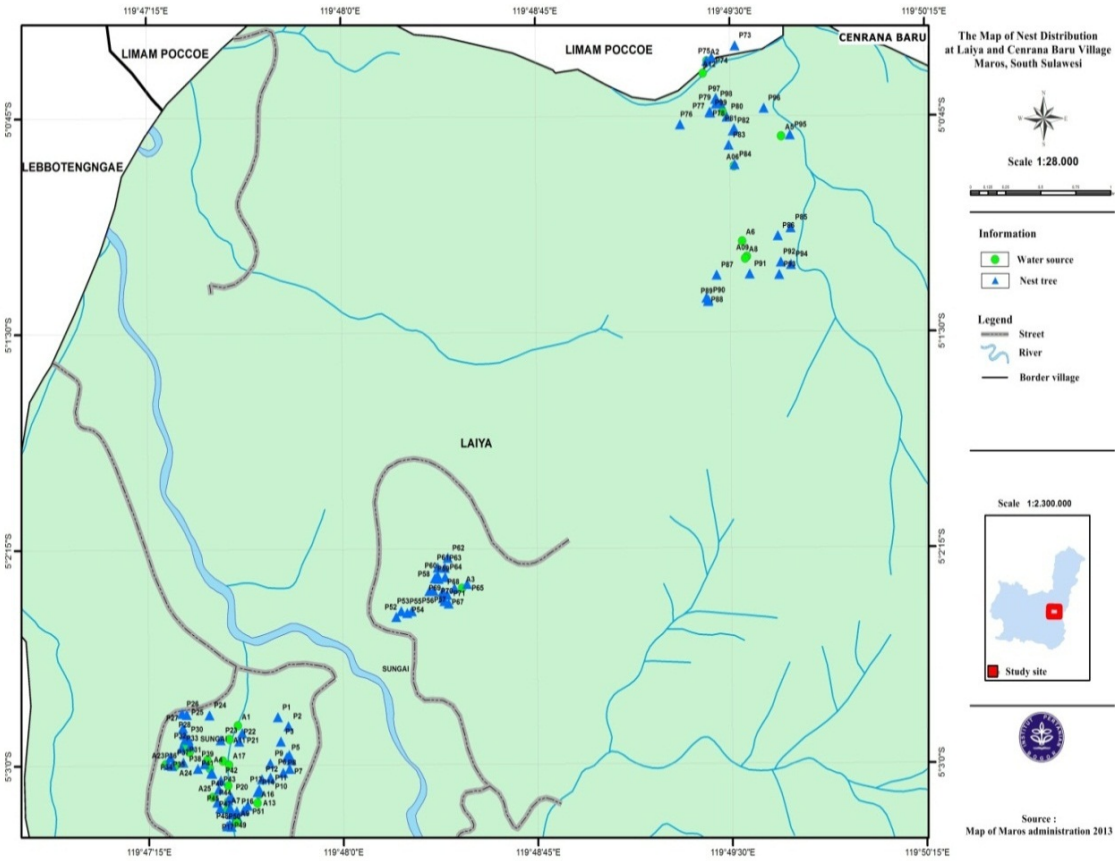

Figure 1. The distribution of *Apis dorsata binghami* nests at Laiya dan Cenrana Baru village.

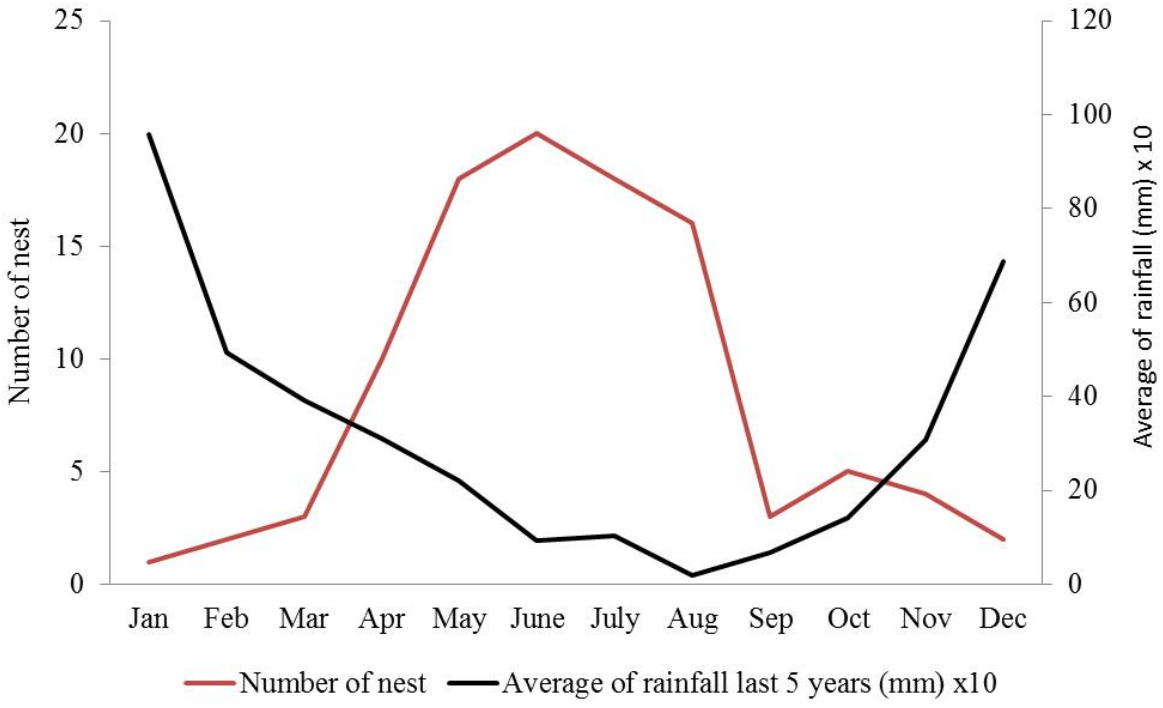

Figure 2. The number of *Apis dorsata binghami* nest related with monthly rainfall in the study sites.

In *F. subulata* and *Adenanthera* sp. plants (7 plants) were found one nest per tree, while in *S. pinnata* were found 7 nests in 5 trees. In *A. sericocarpus, A. scholaris, K. cinerea, L. mappacea* (6 plants) were found one nest per tree, while in *P. obovatum* were found 6 nests in 5 trees. The nest of giant honey bee was rare (1 nest in 1 plant) in *F. annulata* (Fam. Moraceae), *Dracontamelon dao* (Fam. Anacardiacea), *Barringtonia acutangula* (Fam. Lecythidaceae), *Aleurites moluccana* (Fam. Euphorbiaceae), *Buchanania arborescens* (Fam. Anacardiacea), *Arthrophyllum diversifolium* (Fam Araliacea), *Macaranga* sp. (Fam Euphorbiaceae), *Melochia umbellata* (Fam. Euphorbiaceae), *Persea* sp. (Fam. Lauraceae), and *Wendlandia glabrata* (Fam. Rubiacea), except in *Baccaurea* sp. (Fam. Pyllanthaceae), were found 2 nests per tree. In *F. drupacea, S. pinnata, P. obovatum*, and *baccaurea* sp., there were maximum two nests in one tree (Table 1).

Table 1. Nest trees of *Apis dorsata binghami* at Laiya and Cenrana Baru village.

Species of nest trees	Number of Trees	Number of Nests	Types and character of branch
Laiya Village			
Fam. Moraceae			
Artocarpus sericocarpus	6	6	Wood, hard to peel
Ficus subulata	7	7	Wood, hard to peel
F. racemosa	3	3	Wood, hard to peel
F. annulata	1	1	Wood, hard to peel
F. drupacea	2	4	Wood, hard to peel
F. vasculosa	3	3	Wood, hard to peel
F. septica	2	2	Wood, hard to peel
Fam. Apocynaceae			
Alstonia scholaris	4	4	Wood, hard to peel
Fam. Anacardiaceae			
Dracontamelon dao	1	1	Wood, hard to peel
Spondias pinnata	5	7	Wood, hard to peel
Fam. Malvaceae			
Pterospermum celebicum	3	3	Wood, hard to peel
Klenhovia hospita	2	2	Wood, hard to peel
Fam. Euphorbiacea			
Aleurites moluccana	1	1	Wood, hard to peel
Fam. Fabaceae			
Adenanthera sp.	6	6	Wood, hard to peel
Pterocarpus indicus	3	3	Wood, easy to peel
Fam. Sapotaceae			
Palaquium obovatum	4	5	Wood, hard to peel
Palaquium bataanense	2	2	Wood, hard to peel
Fam. Lauraceae			
Litsea mappacea	1	1	Wood, hard to peel
Fam. Aceracea			
Acer laurinum	2	2	Wood, hard to peel
Fam. Myristicaceae			
Knema cinerea	6	6	Wood, hard to peel
Fam. Meliaceae			
Toona sureni	2	2	Wood, hard to peel
Fam. Myrtaceae			

Sysigium sp.	2	2	Wood, hard to peel
Fam. Lecythidaceae			
Barringtonia sp.	2	2	Wood, hard to peel
B. acutangula	1	1	Wood, hard to peel
TOTAL	**71**	**76**	
Cenrana Baru Village			
Fam. Lauraceae			
Litsea mappacea	5	5	Wood, hard to peel
Persea sp.	1	1	Wood, hard to peel
Fam. Apocynaceae			
Alstonia scholaris	2	2	Wood, hard to peel
Fam. Moraceae			
F. racemosa	1	1	Wood, hard to peel
Fam. Sapotaceae			
P. obovatum	1	1	Wood, hard to peel
P. bataanense	1	1	Wood, hard to peel
Fam. Pinaceae			
Pinus merkusii	3	3	Wood, hard to peel
Fam. Fabaceae			
Adenanthera sp.	1	1	Wood, hard to peel
Fam. Anacardiaceae			
Mangifera indica	2	2	Wood, hard to peel
Buchanania arborescens	1	1	Wood, hard to peel
Fam. Araliaceae			
Arthrophyllum diversifolium	1	1	Wood, hard to peel
Fam. Phyllanthaceae			
Baccaurea sp.	1	2	Wood, hard to peel
Fam. Euphorbiacea			
Macaranga sp	1	1	Wood, hard to peel
Fam. Malvaceae			
Melochia umbellata	1	1	Wood, hard to peel
Fam. Rubiaceae			
Wendlandia glabrata	1	1	Wood, easy to peel
Fam. Fagaceae			
Lithocarpus celebicus	2	2	Wood, hard to peel
TOTAL	**25**	**26**	

Characteristics of Nest Sites

The nests of *A. d. binghami* were found varies in height from ground level. In an altitude 0-10.9 meters were found 11 nests, in 11-21 meters were found 40 nests, and in the intervals of more than 21 meters were found 51 nests. Fifty percent of nests were found in 0-20 meters and 50% in altitude more than 21 meters. The lowest nest was found 1 meter above the ground and the highest in 32.6 meters from the ground. The average of nest height from the ground level was 19.2 meters (Fig. 3).

The nests of *A. d. binghami* were found in trees with diameter ranged 0.01 - 2.52 meters, with an average diameter of trees was 0.7 meter. Diameter of nesting trees were grouped into 3, i.e., diameter of 0.0-0.59 meter (55 trees), 0.6-1.0 meter (23 trees) and more than 1.0 meter (18 trees) (Fig. 4).

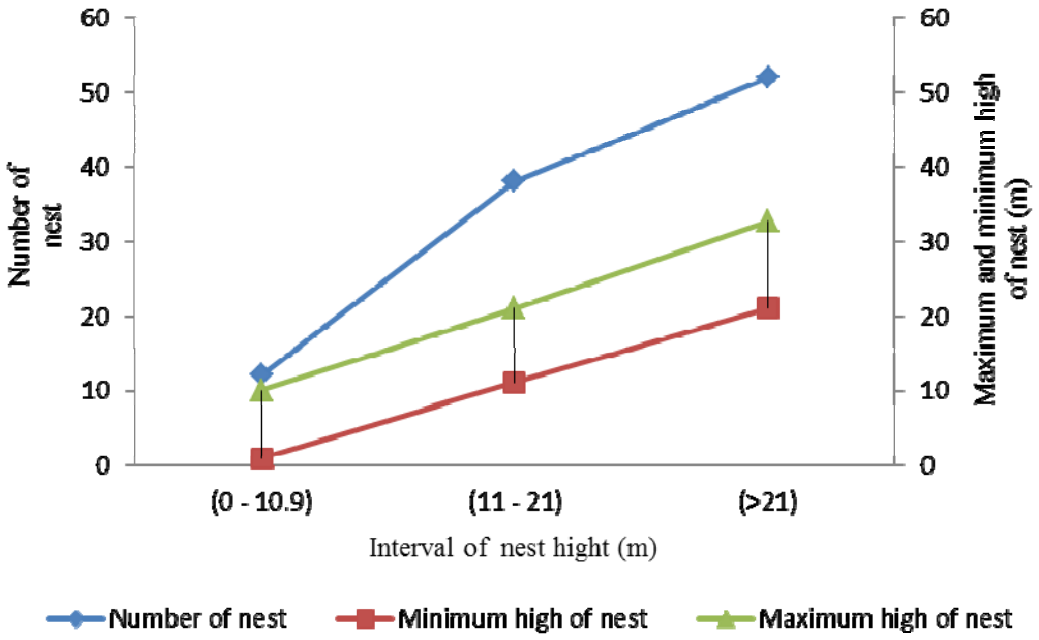

Figure 3. The height of *Apis dorsata binghami* nests from ground surface.

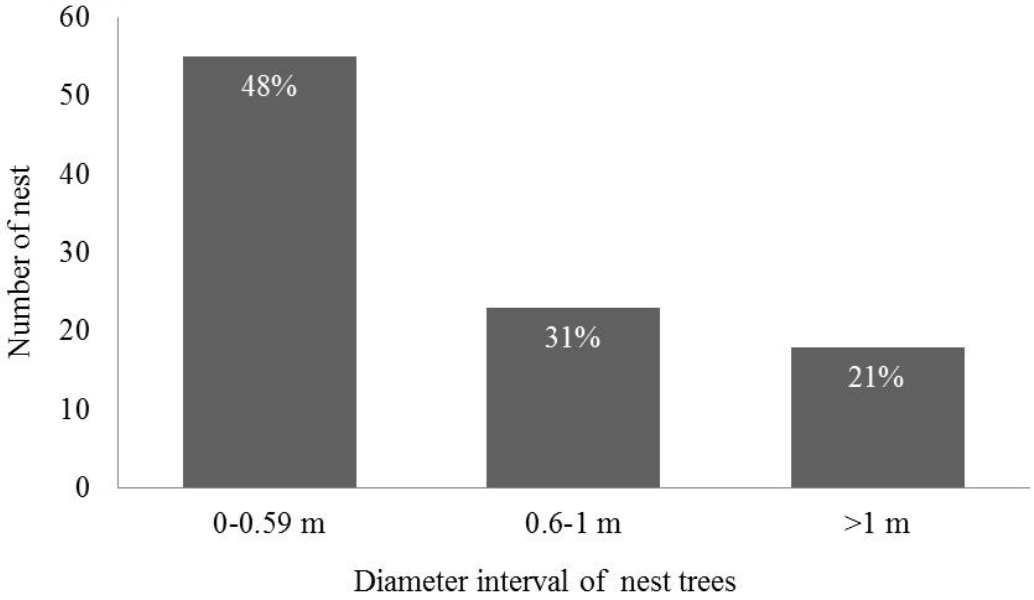

Figure 4. The diameter of trees with *Apis dorsata binghami* nests.

The nests of *A. d. binghami* were found varies in angle from branch elevation. In an elevation 10-30° was found 47 nests. In an elevation of 31-60° was found 49 nests and in an elevation 61-90° was found 6 nests. The average branch elevation of *A. d. binghami* nesting tree was in 38°. Ninety four percent of nests were found in 10-60° (Fig. 5). Branch direction

of nesting trees was also varied. We found 10 nests in branch direction to west, 37 nests was found in branch direction to south, 35 nests was found in branch direction to east, and 20 nests was found in branch direction to north (Fig. 5). Ninety six percent of *A. d. binghami* nests were found in trees with bark of branch hard to peel (98 nests) and 4% (4 nests) were found in trees with bark of branch easy to peel at tree branch of *Pterocarpus indicus* and *W. glabrata.*

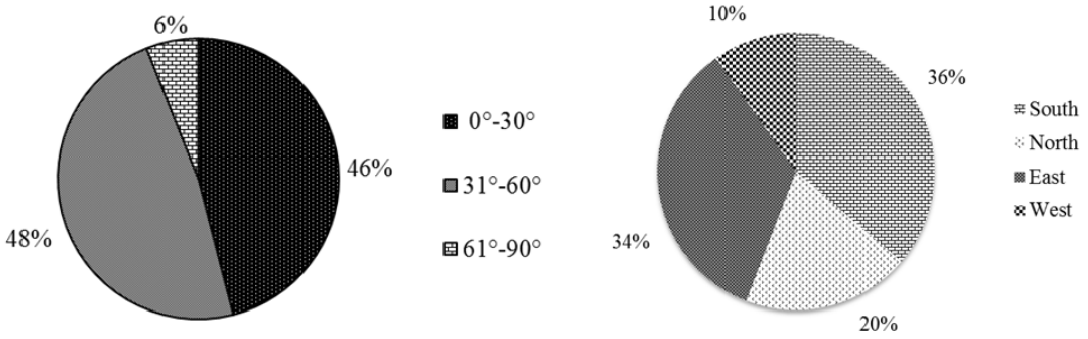

Figure 5. The percentage of branch angle with *Apis dorsata binghami* nests (a) and the percentage of the branch directions of *A. d. binghami* nests (b).

The nests of *A. d. binghami* were found typically constructed in open air. Based on observation, the characteristics of the nest closure condition were grouped into five: (a) protected with canopy and covered by liane plants and leaves (55 nests), (b) protected with canopy and covered by liane plants only (17 nests), (c) protected with canopy and covered by leaves (20 nests), (d) in a open and there is a liane plants (2 nests), and (e) an open and unprotected by foliage and liane plants (8 nests). Ninety percent of nests were found in protected with canopy and protected by liane plants, leaves, or both (Fig. 6).

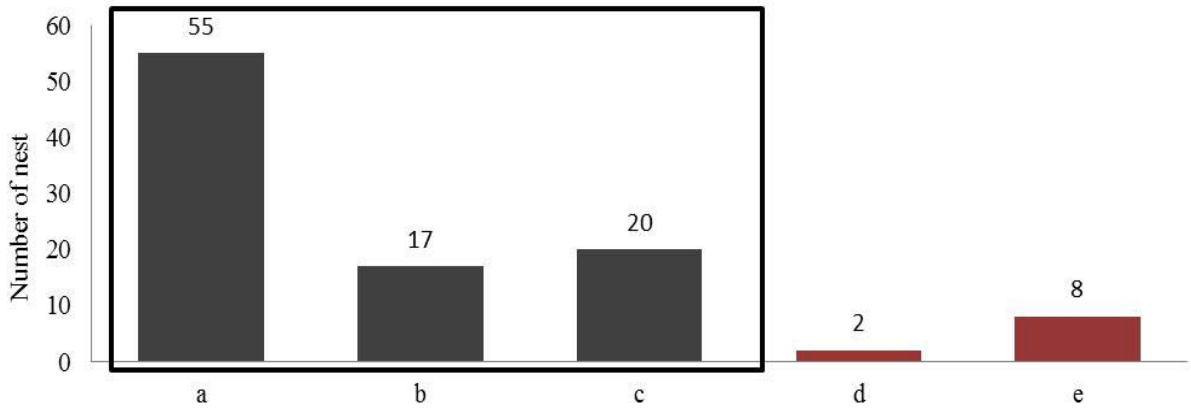

Figure 6. The closure conditions of *Apis dorsata binghami* nests: (a) protected with canopy and covered by liane plants and leaves, (b) protected with canopy and covered by liane plants, (c) protected with canopy and covered by leaves only, (d) unprotected with canopy and there are liane plants and, (e) unprotected with canopy and there are not liane plants and leaves.

We found 102 nests of *A. d. binghami* in primary forest and near the plantation. A total of 92 nests were found at primary forests and 10 nests at a location near the plantation. The distance of nesting tree from water sources also varied from the nearest was 1.5 meter and the farthest was 470 meters (average 118.4 meters) (Fig. 7). Around the nest, the average of temperature was 30°C ± 1.85 (min 24 °C, max 34.4 °C) (Fig. 8), air humidity was 42 % ± 8.45 (min 29 %, max 75 %), wind speed was 4 km/h ± 1.64 (min 1.2 km/h, max 8 km/h), and light intensity was 790 lux ± 630 (min 30 lux, max 512 lux).

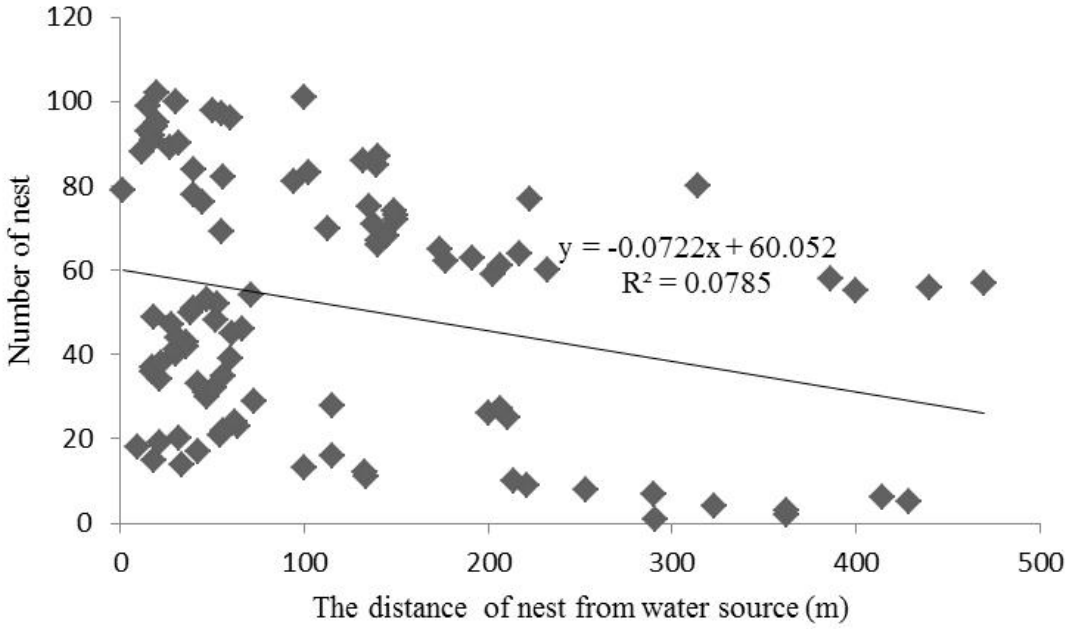

Figure 7. The distance of *A. d. binghami* nest trees from water source.

Figure 8. The temperature around of *Apis dorsata binghami* nest.

Discussion

Based on observations and interviews, there is a certain time colonies of *A. d. binghami* were found due to the migratory behavior. In the study sites, colonies of *A. d. binghami* were generally found in June and July and less in December to March. This is due to the higher rainfall occurred from December to March. Data from the Meteorology and Geophysics Agency Region IV Makassar (2015) showed that in 2010-2014, high rainfall started from December to March. Migration of *A. d. dorsata* occurred at least twice a year and able to migrate up to 200 km from the old nest. Migration of *A. d. dorsata* to better location was caused by deteriorating environmental conditions, such as weather condition, reduced availability of food, and the parasite-eating larvae and pupae (Paar *et al.* 2004; Woyke *et al.* 2004; Momose *et al*. 1998; Rattanawannee & Chanchao 2011, Makinson *et al.* 2014).

In the event of migration, wild honey bees will return to previous nesting place and will build a nest back if the environment is maintained and not changed for the worse (Neumann *et al*. 2000). Based on observation in the study sites, there is one colony of *A. d. binghami* remained two years in the tree without migrating. This occurs because the owner did not harvest the honey from the nest during this period and availability of food and water in the area is enough. Oldroyd & Nanork (2009) stated that the deteriorating forest conditions, lack of water and feed, as well as bee hunting methods that threaten the survival and damage the of bee hives caused migration to a better location.

Nesting tree of *A. d. binghami* was highly variable ranging from small to large trees and low to high trees. A tendency, *A. d. binghami* colonies was not select plant species, the height from the ground, and the direction of branching. Starr *et al.* (1987) reported that subspecies *A. d. dorsata* in Borneo discovered 15 species of nesting trees and it is not chosen to determine nesting tree. Hadisoesilo & Kuntadi (2007) also stated that in Riau, nesting trees of *A. dorsata* were in banyan (*Ficus* sp.), kempas (*Koompassia excelsa*), lumbuai (*Metroxylon* sp.), siluang (*Polythias hipolenca*), jangkang (*Dellenia exinia*), and mahang (*Macaranga* sp.). Whereas in Sulawesi, nesting trees of *A. d. binghami* were in durian (*Durio zibethinus*), mango (*Mangifera* sp.), guava (*Syzygium* sp.), and *Ceiba pentandra.* Some studies have also found *A. d. dorsata* tend to like kempas (*K. excelsa*) for nesting (Starr *et al.* 1987; Hadisoesilo 2001). In Bogor Botanical Garden, West Java, *A. dorsata* tend to choose *Ficus albipila* as nesting trees (up to 72%) (Kahono *et al*. 1999). The colonies of *A. d. binghami* build nests in trees depending on the species of trees that dominate in these areas. (Hadisoesilo & Kuntadi 2007).

Ten percent colonies of *A. d. binghami* were found less than 10 meter from ground surface and more than 90% within 10 meters. Kahono *et al*. (1999) also reported that nests of *A. dorsata* were found in a height less than 10 meter from ground surface over a period of two years. While, Weihmann *et al*. (2014) reported that *A. dorsata* prefer high trees to make their nests. Previous studies reported that *A. dorsata* tend to prefer places with a height of more than 10 meters to built nests (Starr *et al.* 1987; Kahono *et al*. 1999; Hadisoesilo 2001). The height nest of *A. d. binghami* probably related to the type of its predators. The nest site located in high trees was aimed to avoid the vertebrate predators (Starr *et al*. 1987) and nests located in low altitude from the ground surface indicate the lack or absence of predators.

The giant honey bees, *A. d. binghami* build nests in open areas and tend to prefer trees with conditions protected with canopy and covered by liane plants, foliage, or both. In contrast, Starr *et al*. (1987) reported that *A. d. dorsata* tend to built a nest in an open air location and clean by liane plants. Weihmann *et al*. (2014) also reported that *A. d. dorsata* tends to built nests on open so that the circumstances are more easily seen by predators, such

as wasp *Polistes olivaceus*. The weaker colony defense caused the higher risk of larvae and colonies attacked by disease. The wild honey bees usually build grouped nests in the same tree by hanging on a tree branch that is clean and free of epiphytic plants (Hadisoesilo & Kuntadi 2007; Roy *et al*. 2011).

Based on the observation and interview with the local community, nesting behavior of *A. d. binghami* was different to maintain the colony from predators, such as birds. Oldroyd and Nanork (2009) stated several species of birds as predators of honey bees, such as *Indicator xanthonotus*, *I. archipelagicus*, *Pernis ptilorhyncus*, and *P. celebensis*. Additionally, colony of *A. d. binghami* also tend to nest with a slope of branch is 10°-60° (94%) and their build nest in trees with bark of branch hard to peel (96%). This results supported Kahono *et al*. (1999) reported that the colony of *A. d. dorsata* found in Kebun Raya Bogor, West Java, Indonesia tend to nest on a branch with a slope of 50°. The colony of *A. d. dorsata* never built the nests on old buildings, weak branch or dead trees because it was not strong enough to support the load of the nest (Neupane *et al*. 2013).

The condition around the nests was primary forest with dense vegetations and varied the species of trees. These conditions support availability of food resources, pollen and nectar, for the survival of *A. d. binghami* colonies. Woyke *et al*. (2012) reported the flowering season in early December in Nepal causes a lot of bees come to the area and they emigrate in April and May when the flowering season was over. Moreover, the existence of water resources is also important for bee colonies. The water is used to the process of nest cooling on honeycomb (Ruttner 1988). In the field observations, we also found *A. d. binghami* worker at the nearest water source. Hepburn and Radloff (2011) stated that the limited availability of water resources will also cause migrate of bees colony to new location.

The humidity around the nesting tree was 29-74%. and temperature was 24-34.4°C The activities of bees fly will be reduced at low temperature and high humidity, because in that situation the energy required in order to achieve greater insect thorax temperature of 35-40°C to fly for foraging (Heinrich 1979). Activities of bees foraging were heavily influenced by food availability and environmental conditions around the nest (Gottlieb *et al.* 2005; Sadeh *et al.* 2007).

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References

Appanah S. 1993. Mass flowering of dipterocarp forests in the aseasonal tropics. *Journal of Biosciences* 18(4): 457–474.

Bawa K. S. **1990.** Plant-pollinator interactions in tropical rain forest. *Annual Review of Ecology Systematics* 21:399–422.

Bertoni R. 2013. Measures comparison of body parts of worker's *Apis dorsata* (forest bee) at four locations. Essay. Bogor (ID). Bogor Agricultural Institute.

Bookhout T. A. 1996. *Research and Management Techniques For Wildlife And Habitats* Kansas (US): Allen Press Inc.

Corlett R. T. 2004. Flower visitor and pollination in the oriental (Indomalayan) region. *Biological Reviews* 79: 497–532.

Engel M. S. 2012. The honey bees of Indonesia (Hymenoptera: Apidae). *Treubia* 39:41–49.

Franks N. R., Pratt S. C., Mallon E. B., Britton N. F. & Sumpter D. J. T. 2002. Information flow, opinion polling and collective intelligence in house-hunting social insects. *Philosophical Transactions of the Royal Society of London* 357: 1567–1583.

Gottlieb D., Keasar T., Shimida A. & Motro U. 2005. Possible foraging benefits of bimodal daily activity in *ProXylocopa olivieri* (Lepeletier) (Hymenoptera: Anthophoridae). *Environmental Entomology* 34: 417–424.

Hadisoesilo S. 2001. Diversity of Indonesia original honey bee. Research Center and Development for Forest and Nature Conservation, Bogor. *Biodiversitas* 2: 123–128.

Hadisoesilo S. & Kuntadi. 2007. Traditional wisdom in aquaculture forest bee (*Apis dorsata).* Department of Forestry Research and Development Agency of Forestry. Research Center and Development for Forest and Nature Conservation. Bogor. ISBN: 978-979-3145-38-9.

Heinrich B. 1979. *Bumblebee Economics*. London (GB). Harvard Univ Pr.

Hepburn R. & Sarah E. Radloff. 2011. *Honey Bees of Asia*. New York (US). Springer-Verlag Berlin Heidelberg.

Itioka T., Inoue T., Kaliang H., Kato M., Nagamitsu T., Momose K., Sakai S., Yumoto T., Mohamad S. U., Hamid A. A. & Yamane S. 2001. Six-year population fluctuation of giant honey bee *Apis dorsata* (Hymenoptera: Apidae) in tropical lowland dipterocarp forest in Sarawak. *Annals of the Entomological Society of America*. 94: 545–549.

Kahono S., Nakamura K. & Amir M. 1999. Seasonal migration and colony behavior of the tropical honeybee *Apis dorsata* F. (Hymenoptera: Apidae). *Treubia* 31(3): 283–297.

Lo N., Gloag R. S., Anderson D. L. & Oldroyd B. P. 2010. A molecular phylogeny of the genus *Apis* suggests that the giant honey bee of the Philippines, *A. breviligula* Maa, and the plains honey bee of Southern India, *A. indica* Fabricius, are valid species. *Systematic Entomology* 35: 226–233.

Makinson J. C., Schaerf T. M., Rattanawannee A., Oldroyd B. P. & Beekman M. 2014. Consensus building in giant honey bee, *Apis dorsata,* swarms on the move. *Animal behavior* 93: 191–199.

Mead D. 2013. A guide to some bees and wasps of Indonesia. Sulang Language Data and Working Papers: Topics in Lexicography, no. 11. Sulawesi Language Alliance. http://sulang.org/

Momose K., Yumoto T., Nagamitsu T., Kato M., Nagamasu H., Sakai S., Harrison R. D., Itioka T., Hamid A. A. & Inoue T. 1998. Pollination biology in a lowland dipterocarp forest in Sarawak, Malaysia. I. characteristics of the plant-pollinator community in a lowland dipterocarp forest. *American Journal of Botany* 85(10): 1477–1501.

Neumann P., Koeniger N., Koeniger G., Tingek S., Kryger P. & Morits R. F. A. 2000. Home site fidelity of migratory honey bees. *Nature* 406: 474–475.

Neupane K. R., Woyke J. & Poudel S. M. 2013. Nesting Site-preference and behavior of giant honey bee *Apis dorsata.* Paper presented on Apimondia, 29 September - 4 October 2013, Kyiv, Ukraine. http;//jerzy_woyke.users.sggw.pl/2013_neupane_nesting_site_apimondia.doc and published on abstract and working procedure Apimondia, 2013.

Oldroyd B. P., Osborne K. E. & Mardan M. 2000. Colony relatedness in aggregations of *Apis dorsata* Fabricus (Hymenoptera: Apidae). *Insectes Sociaux* 47: 94–95.

Oldroyd B. P. & Nanork P. 2009. Conservation of Asian honeybees. *Apidologie* 40: 296–312.

Paar J., Oldroyd B. P., Huettinger E. & Kastberger G. 2004. Genetic structure of an *Apis dorsata* populations: the significance of migration and colony aggregation. *Journal of Heredity* 95: 119–126.

Partap U. 2011. The pollination role of honeybees. In: Hepburn, H.R., Radloff, S.E. (eds.) Honeybees of Asia, pp. 227–255. Springer-Verlag, Berlin.

Raffiudin R. & Crozier R. H. 2007. Phylogenetic analysis of honeybee behavioral evolution. *MPE* 43:543–552.

Rattanawannee A. & Chanchao C. 2011. Bee Diversity in Thailand and the applications of bee products, changing diversity in changing environment, Ph.D. Oscar Grillo (Ed.), ISBN: 978 953-307-796-3, InTech, Available from: http://www.intechopen.com/books/changing-diversity-in-changingenvironment/bee-diversity-in-thailand-and-the-applications-of-bee products.

Roy P., Leo R., Thomas S. G., Varghese A., Sharma K., Prasad S., Bradbear N., Roberts S., Potts S. G. & Davidar P. 2011. Nesting requirements of the rock bee *Apis dorsata* in the Nilgiri Biosphere Reserve, India. *Tropical Ecology* 52(3): 285–291.

Ruttner F. 1988. *Biogeography and Taxonomy of Honeybees*. New York (US). Springer-Verlag Berlin Heidelberg.

Sakagami F. S., Matsumara T. & Ito K. 1980. *Apis laboriosa* in Himalaya, the little known world largest honeybee (Hymenoptera: Apidae). *Insect Matsumurana* 19: 47–77.

Sarwono B. 2001. *Honey Bee*. Jakarta: Agromedia Pustaka.

Sadeh A., Shmida A. & Keasar T. 2007. The carpenter bee *Xylocopa pubescens* as an agricultural pollinator in greenhouse. *Apidologie* 38: 508–517.

Seeley T. D. 1985. *Honeybee Ecology A Study of Adaptation in Social Life*. Princeton University Press. Princeton, New Jersey, United Kingdom.

Starr C. K., Schmidt P. J. & Schmidt J. O. 1987. Nest site-preferences of the giant honey bee, *Apis dorsata* (Hymenoptera: Apidae), in Borneo. *Pan Pasific Entomologist* 63(1): 37–42.

Suwannapong G., Benbow M. E. & Nieh J. C. 2011. Biology of Thai honeybee: natural history and threats. In: Bees: biology, threats and colonies. Editor: Richard M. Florio. Nova Science Publishers, Inc. pp. 1–98.

Thomas S. G., Varghese A., Roy P., Bradbear N., Potts S. G. & Davidar P. 2009. Characteristics of trees used as nest sites by *Apis dorsata* (Hymenoptera, Apidae) in the Nilgiri Biosphere Reserve, India. *Journal of Tropical Ecology* 25: 559–562.

Tongco M.D.C. 2007. Purposive sampling as a tool for informant selection. *Ethnobotany Research and Applications* 5: 147–158.

Weihmann F., Waddoup D., Hotzl T. & Katzberger G. 2014. Intraspesific aggression in giant honey bees (*Apis dorsata*). *Insects* 5: 689–704. doi: 10.3390/insects5030689.

Woyke J., Wilde J. & Reddy C. C. 2004. Open air nesting honey bees *Apis dorsata* and *Apis laboriosa* differ from the cavity nesting *Apis mellifera* and *Apis cerana* in brood hygiene behaviour. *Journal of Invertebrate Phatology* 86: 1–6.

Woyke J., Wilde J. & Wilde M. 2012. Swarming and migration of *Apis dorsata* and *Apis laboriosa* honey bees In India, Nephal and Bhutan. *Journal of Apicultural Science* 56(1): 81–91. doi: 10.2478/v10289-012-0009-7

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