Journal of **BIOLOGICAL RESEARCHES**
Berkala Penelitian Hayati
ISSN: 08526834 | E-ISSN:2337-389X
Volume 22| No. 1| December | 2016

Original Article

Flowering of *Areca catechu* in Bogor Botanic Gardens

Angga Yudaputra*, Rizmoon N. Zulkarnaen, Irvan F. Wanda, Joko R. Witono
Bogor Botanic Gardens, Center of Plant Conservation

Abstract

Areca catechu is a species of palms that widely distributed in Indonesia. This palm has unique characteristics and important roles of a tropical forest ecosystem. Indonesian local tribes used seed of this palm for traditionaly medicinal purposes. Information regarding of flowering of *A.catechu* is valuabe to support a genetic improvement program. Currently, the flowering information about this palm is still lack, thereby study that related with flowering of *A. catechu* is important to be conducted. This study aimed to provide information about the flowering of *A.catechu* species. The observation was started with randomly selection of three individuals *A. catechu* from the Moluccas island. There were 3 main observations which done in this study, included the observation of flowering phases period, morphological changes of each phases, and the micro-climate factors. Flowering *A. catechu* was categorized into 4 phases, including initiation, bud towards anthesis, anthesis and young fruit to maturity. Each of flowering phases have a different time. The flowering phases were not directly influenced by micro-climate factors. *Trigona laeviceps* was the most dominant insect visitor and wind was an abiotic factors that influenced the flowering of *A. catechu.*

Key words: *Areca catechu*, flowering, *Trigona laeviceps*.

Received: 11 November 2016 Revised: 13 December 2016 Published: 15 March 2017

Introduction

Betel nut palm (*Areca catechu*) belongs to the family Palmae or Arecaceae. The palm reaches a mature height of 15-20 m, with a trunk 15 cm in diameter. The seed germination completed by 90 days, and after four months will be shaped leaf crested unbranched. A trunk is formed in the second year. Flowers are unisexual, with both male (*staminate*) and female (*pistillate*) flowers borne in the same inflorescence. Inflorescences are crowded, much-branched panicles borne below the leaves. Each terminal branch has a few female flowers borne at the base and numerous male flowers extending from there out to the branch tip. Flowers of both sexes have six tepals, are stalkless (*sessile*), creamy-white, fragrant; male flowers are minute, deciduous, have six stamens, arrowhead-shaped anthers, rudimentary ovary; female flowers are larger (1.2-2 cm long), with six small sterile stamens and a three-celled ovary bearing a triangular stigma with three points at the apex (Staples and Robert, 2006).

Flowering phase begins at 4-6 years of age. Trees begin to bear at 7-8 years, reach full bearing at 10-15 years, continue to yield until the age of 40 years, then persist in a sterile state until death. The first inflorescences may contain only male flowers and consequently do not produce nuts. First flowering may not produce male flowers and fruit. At each inflorescence there are 644 female flowers and male flowers 15000-48000 (Murthy, 1977).

A. catechu is found in environment with evenly distributed rainfall. Although it can grow in mountainous areas, but optimum growth is in lowland areas. This palm can grow at an altitude of 0-1000 above sea level, with a temperature of 14-36°C, with a rainfall rate of 750-4500 mm/year. This palm is also found in soil conditions with high carbon content and a pH range from acidic to neutral (Orwa *et al*., 2009).

A. catechu has a wide distribution range, is found in India, Malesian, Taiwan and other countries in East Asia. This palm has economic value and can be used as medicine (Jaiswal *et al.*, 2011). According to Sharan (1996), This palm is used to cure various type of diseases such as leukodema, anemia and obesity. Flowers commonly is used in mixed salads. Flowers, young shoots, leaves and roots are used for a variety of medicines. Seeds contain alkaloids, tannins, polyphenol, sugars and lipids. Seeds also contain antifungal, antibacterial, anti-inflammatory and antioxidant (Wetwitayaklung *et al*., 2006). This palm produces secondary metabolites that function as a defense mechanism against microorganisms and insects. *A. catechu* contains several type of alkaloids including arecoline, arecaidine, guvacine, and guvacoline. Arecaidine play a role in the stimulation of collagen synthesis, arecoline act as an activator ligand (Boucher and Mannan, 2002).

Information about flowering of *A. catechu* is quite useful to provide knowledge about flowering aspect and improve plant breeding programs, specifically when carry out the assembly of high yielding varieties through hybridization on the future. Variety assemblages are always associated with the readiness of the plants to be pollinated artificially. The accomplishment of outcrossing programmes requires information about the flowering phases (Jamsari *et al.*, 2007). According of aforementioned statements, study related with flowering *A. catechu* should be conducted.

* Corresponding Author:
Angga Yudaputra
Bogor Botanic Gardens, Center of Plant Conservation
Ir. H. Juanda 13, Bogor, Central Java, Indonesia.
Telp: 085777124840 Fax: (0251) 8311362
e-mail : yuda_science@yahoo.com

http://dx.doi.org/10.23869/bphjbr.22.1.20167

Methods

This study was conducted in August 2014-July 2015 in Bogor Botanic Gardens. We used 3 individuals of *A. catechu* from Moluccas Island. The tools included digital cameras, black or red cloth, a ruler, vernier caliper, tweezers, magnifying glass, yellow label with lace, garden shear, knife, insect trap, soil tester, LM-8000 (lightmeter, anemometer, hygrometer, thermometer), Microscope with optical Camera SZ-CTV.

Sample Selection

The flowering observations was conducted toward 3 individuals of *A.catechu* which located in X.D.155 F, G and I (figure 1). We selected three individuals of this palm that already entered flowering initiation phase. The selected individuals were marked with a yellow label to simplify the observation. Some of aspects that were observed in this study including flowering period, morphological changes and micro-climate factor. The observation covered length of flower initiation period, flower buds toward anthesis, anthesis flowers and young fruit to maturity. Furthermore, time period from each of these phases were observed.

Morphology

Flower development of *A. catechu* in each of phases were documented with a digital camera to gain the sequential data. Observation of morphological changes used several parameters (shape, size and color). Small flower organs were observed using a microscope, while length and width measurements of flower organs performed by a ruler and calipers. In this study also calculated a number of male and female flowers to determine the number of successful female flowers to be pollinated.

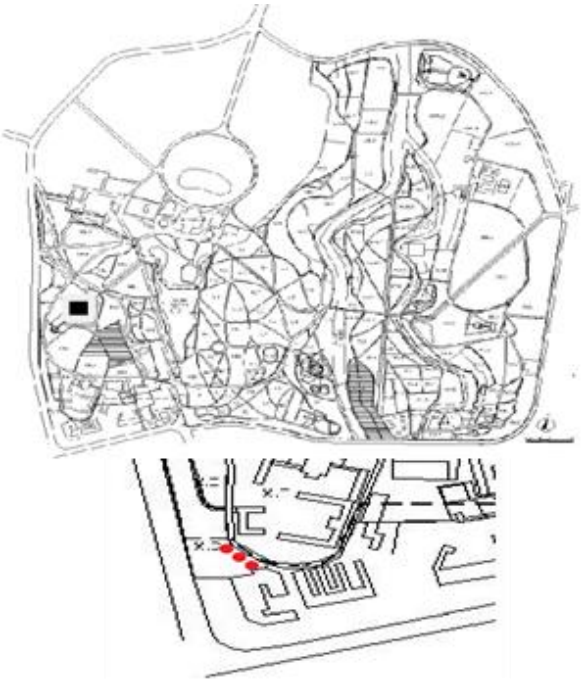

Figure 1. Location of three samples of *A. catechu* in Bogor Botanic Gardens

Biotic and Abiotic Factors

The observed factors consisted of biotic and abiotic factors. Biotic factor was "the insect visitors" from flower of *A.catechu* which were suspected as pollinators. An insects which were located around flowering, were captured, recorded and identified. The observation of insect visitors was conducted at three different times (8:00 am to 10:00 am), (11:00 am to 01:00 pm) and (03:00 pm to 05:00 pm). Abiotic factors that recorded intensity of light in the shade and outer shade, humidity, wind speed, temperature, precipitation, soil pH and soil moisture. The observation of abiotic factors was conducted at 12:00 am to 01:00 pm by using Luxtron LM 8000, soil tester.

Data Analysis

Data analysis was performed to determine the phase of the development of flowers. Descriptive data were grouped by character (shape, size and color). Micro-climate data taken from maximum and minimum values. Observation result of each samples will be compared to get the flowering phase in *A.catechu.*

Results

Flowering observation of *A. catechu* that located in the area X.D.155 F, X.D.155 G and X.D.155 I, have a different flowering period (table 1).

Figure 2. Morphology *A.catechu* in Bogor Botanic Gardens. a. Individual of *A. catechu* in X.D.155 F; b. Individual of *A. catechu* in X.D.155 G; c. Individual of *A. catechu* in X.D.155 I.

Table 1. The flowering period of *A.catechu.*

Flowering phases	Time period (day)		
	Individual (locations X.D.155 F)	Individual (locations X.D.155 G)	Individual (locations X.D.155 I)
Initiation	11	9	10
Bud towards anthesis	6	7	12
Anthesis	4	4	3
Young fruit towards maturity	191	191	204
Total Duration	211	211	229

Table 2. Flowering phase

Flowering phase	Individual (locations X.D.155 F)	Individual (locations X.D.155 G)	Individual (locations X.D.155 I)
Initiation	Flowers shielded sheath in leaf midrib (Fig. 2a); midrib withered yellow-brown (Fig. 2b); end initiation marked with leaf turns brown, their decay in the upper end of midrib (Fig. 2 b), torn at the base of the leaf midrib (Fig. 2c) and the collapse of the leaf midrib (Gb. 2d).	Flowers shielded sheath in leaf midrib (Fig. 2a); midrib withered yellow - brown (Fig. 2b); late initiation characterized by the decay at the top end of the frond and shredded leaf midrib (Fig. 2c).	Flowers shielded sheath in leaf midrib (Fig. 2a); wilting yellow-brown midrib (Fig. 2b); end of initiation was marked with shredded leaf midrib (Fig. 2c dan 2 d).
Bud towards anthesis	Spiral, yellow, length 55- 65 cm.	Spiral, yellow, length 50-65 cm.	Spiral, white – yellow, length 35-45 cm
Anthesis	Torn sheath in front (Fig. 4a); inflorescence infrafoliar (Fig. 4b); number of rachis 15 number of rachila 200-215, length 22-25cm.	Torn sheath in front (Fig. 4a); inflorescence infrafoliar (Fig. 4b); number of rachis 13, number of rachila 220-230, length 22-25cm.	Torn sheath in front (Fig. 4a); inflorescence infrafoliar (Fig. 4b); number of rachis 5, number of rachila 85-90, length 22-25cm.
Young fruit towards maturity	From 83 female flowers, 6 fall off and 77 grow become fruits	from 79 female flowers, 19 fall off and 60 grow become fruits	From 34 female flowers, 12 fall off, 8 drought and fall off dan 6 grow become fruits and 1 small fruit.

Table 3. Micro-climate factors.

Parameter	Micro-cimate factors							
	light intensity (Lux) shading	light intensity (Lux) without shadding	temperature (^{0}C)	humidity (% RH)	wind speed (m/second)	soil pH	soil moisture (%)	rainfall (mm)
The detached leaf midrib	7100-8920	16760-19210	31 - 32. 3	53.3 - 55.4	0.3 - 0.5	6.8 -7	68 -70	0
Open it up sheath	15620-16120	13740-18790	31 - 31.6	54 - 56. 5	0	6.8 - 7	54 - 55	0
Male flowers shed	13200-14110	18780-19900	33 - 34.5	44 - 46.5	0.6 - 0.9	6.9 -7	60 - 63	0-0.5
Fruit maturity	13340-14550	15690-16780	34.3 - 35.3	46 - 48.2	0 - 0.3	7 -7.1	60 - 62	0-0.3

The flowering phases of A. catechu consist of 4 phases. There are including initiation phase, bud phase toward anthesis, anthesis phase, and young fruit to mature phase. Those phases were delineated in this following picture below.

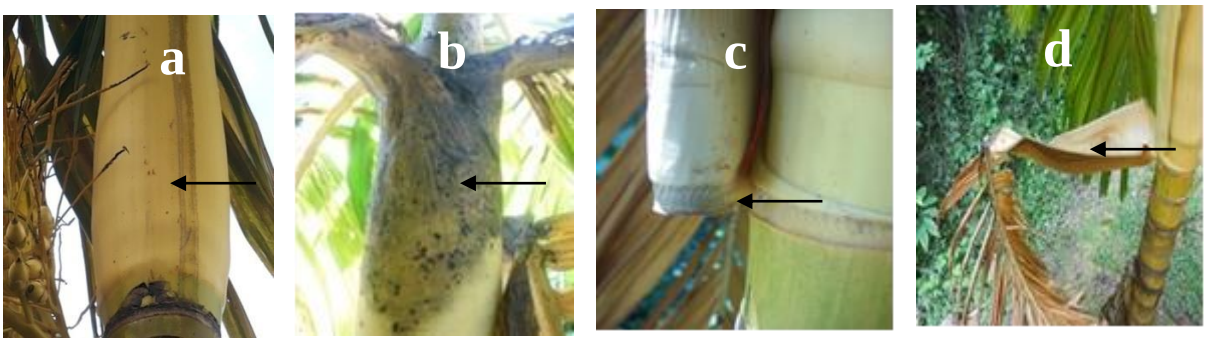

Figure 3. Initiation phase of flowering *A. catechu* a. Flowers shielded sheath in leaf midrib (early initiation); b. Leaf sheaths wither and rot; c. Leaf sheaths tear at the base ; d. Fall leaf midrib (end of initiation)

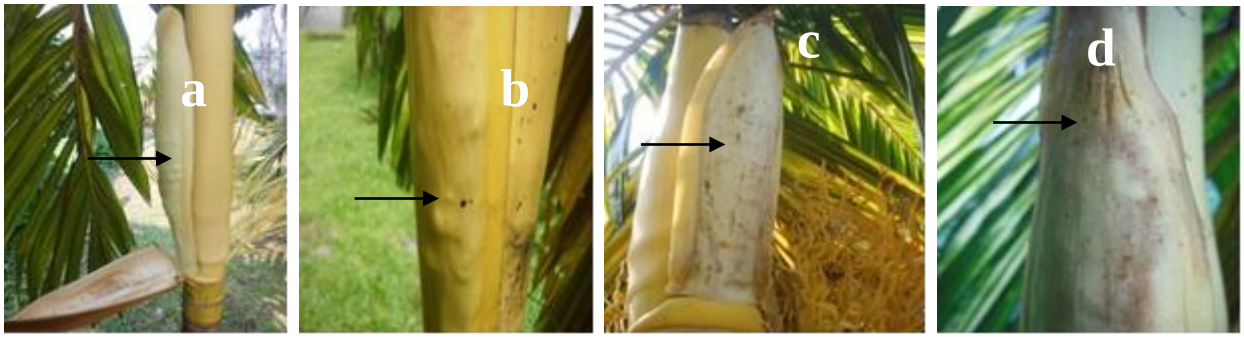

Figure 4. Buds phase towards anthesis. a. Flowers in the sheath (early phase of bud towards anthesis); b. Sheath sizes flowering enlarged; c. Sheath changes color to brown; d. edge sheath withered and folded

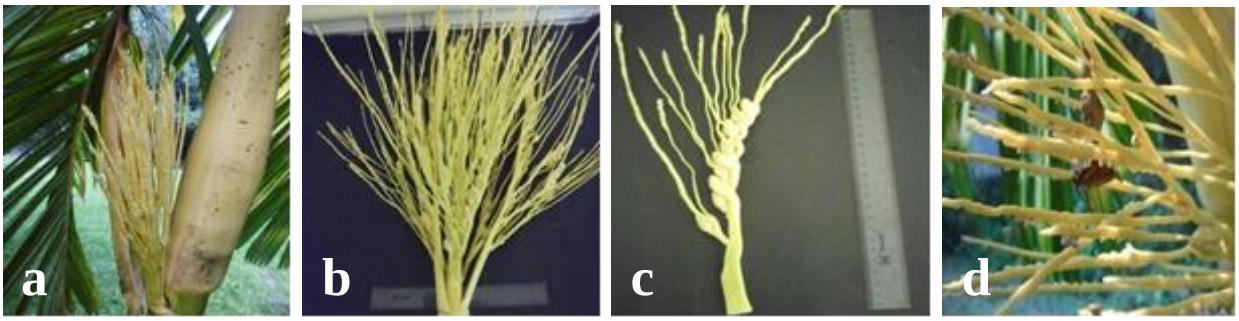

Figure 5. Anthesis phase. a. Flower sheath torn (early anthesis); b. Flowering *A. catechu* ; c. Rachis and rachila flowering *A. catechu*.; d. male flowers begin to shed (end of anthesis)

Figure 6. Young fruit ripening phase towards *A. catechu*

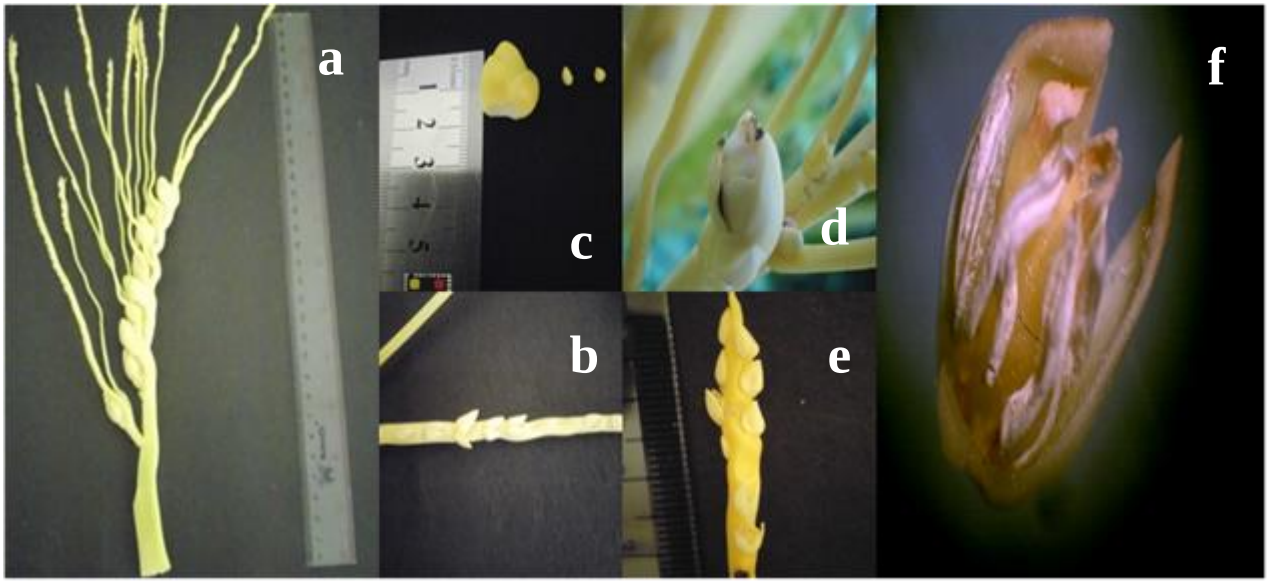

Figure 7. Male and female flowers : a. male and female flowers on the flowering; b. male and female flowers are not blossom; c. female flowers blossom; d. male flowers are in pairs; e. single male flowers located linear lined along rakhila; f. male flower stamen

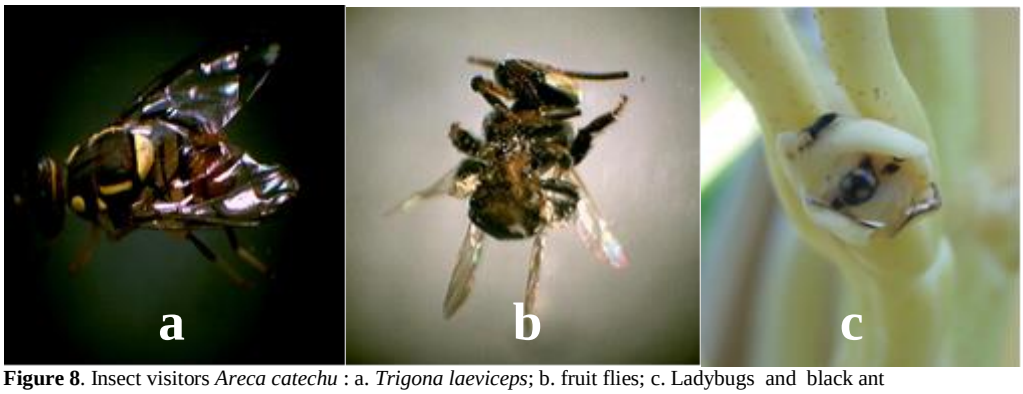

Figure 8. Insect visitors *Areca catechu* : a. *Trigona laeviceps*; b. fruit flies; c. Ladybugs and black ant

Discussion

Flowering period of *A.catechu* was different from *A.vestiaria* which has flowering period of 75-98 days (Fitriani, 2013). In every phase of flowering included four phases, those are flower initiation phase, bud phase towards anthesis, anthesis phase and fruit development phase. Flowering influenced by environmental factor such as duration of sun irradiation, temperature, and humidity. Flowers are a tool for plant breeding. Flowering, pollination and fertilization are important events in the reproduction of plant (Dafni, 1993).

Initiation phase was the phase which changes morphologically flower buds. The initiation phase was characterized by the withering of leaf midrib, color changes to brown of leaf midrib, and the leaves change color to yellow (Table 2). Partially torn leaf midrib at 7:00 am to 9:00 a.m and leaf midrib was detached away from the stem at 01:00 pm to 03:00 pm. Development phase of flower buds towards anthesis included differentiation of parts of the flower, the formation of the structure of male and female flowers, the size of the spindle (sheath) flowering growth, sheath color changes and the inclination of the rod which increases in each overtime (Table 2). Flowering will enter the phase of anthesis after the color was changed from yellow to brown of sheath.

Anthesis phase was started from cracking of sheath until the death of male flowers. After sheath cracked, flowers emitted a fragrant smell. Sheath cracked at 7:00 am to 8:00 pm. Sheath opened to be apart of flowering at 03:00 pm to 04:00 pm. In individuals (location X.D.155 I) sheath that dried first, took 2 days to detach away from flowering. Commonly, flowering of *A. catechu* had 13-15 rachis and every rachis consisted at least 20-29 rachila. Inflorescence of *A. catechu* appeared under the canopy of midrib. In this phase, the male flowers will blossom. At the same time, this phase will be followed by flowering of female flowers (protandrous). Male flowers will blossom after 10-13. Whereas, the female flower will blossom after 15-19 days.

The last phase was the phase of the young fruit becomes maturity, marked with additional sizes from flowers that have been pollinated. There were some flowers that blossom while it was still inside the sheath, sometimes, the flowers would fall off during the process. Ripening of the fruit will be followed by changing of rachila color to brown, the tip part of rachila would wither.

Fruit was round or oval in shape. The young fruit was yellow, the color of fruit was not changed until the fruit

became ripe . Ripe fruit was larger than the young fruit. Phase of young fruit towards maturity took 191-204 days. Data on average period of flowering phase and a flowering of *A. catechu* may be used to determine the harvesting time of *A. catechu.*

The Factors that Affect the Flowering of *A. Catechu*

Flowering of A. catechu was influenced by two factors: biotic and abiotic factors. A biotic factor that observed in this study is that the visit of insect pollinators on flowering of *A. catechu*. Insect visits occurred at 08:00 am to 09:00 pm at anthesis phase. The highest frequency of insect visits occurred at 11:00 am to 12:00 am (all types of insect visitors), whereas at the other times only found ladybugs, fruit flies and ants. Insect visit was dominated by black ants. Visits of insects were found in anthesis phase since cracking of sheath until the death of the male flowers. Insect visitors, in terms of *T. laeviceps* and ladybugs were found in all the individuals. *T. laeviceps* was the most dominant insect visitors. *T. laeviceps* was suspected an insect pollinators of flowering *A. catechu*. These predictions were based on the observation of the structure under the body of this insect, which found pollen in the insect body. These insects were found in *A. catechu* inflorescence after the female flowers blossom.

T. laeviceps is a bee that has unique characteristics with korbikula (pollen basket) on the outer surface of the tibia hind limbs, the hair on its body surface and a long proboscis. Body's structure makes *Trigon*a sp. as the main pollinators of many plant species (Michener, 2000). *T. laeviceps* were also found in the type of mace (*Myristica fragrans*), pacar air flower (*Impatiens balsmina*), and cocoa flowers (Masfifah, 2010). Trigona laeviceps, ladybugs, black ants and fruit flies were insect visitors that found in all individuals.

Flowering of *A. catechu* was not directly affected by certain abiotic factors such as light intensity, wind temperature, humidity, soil pH, soil moisture and rainfall. The environmental conditions around the Bogor Botanic Gardens at the time of observation was stable. Wind speed was suspected to affect the pollination process because the location of the male flowers in above of the female flowers. It was possible if transport of pollen to the stigma for pollination through a high wind speed.

Each of flowering phases of *Areca catechu* in Bogor Botanic Gardens has a different time. An insect visitors of *A. Catechu* were *Trigona laeviceps*, ladybugs, fruit flies and black ants. *T. Laeviceps* is a dominant insect visitor. This insects was suspected as insect pollinators agent of *A. catechu*. Flowering phases of *A. catechu* that observed were not directly affected by abiotic factors. Abiotic factors that suspected influence pollination process was wind speed.

Acknowledgements

Thanks given to Dr. Sih Kahono and Dr. Awit Suwito who gave their time to identify the "insect visitors" in *A. catechu*. A lot of thanks given also to Dr. Andria Agusta who gave some suggestions in the writing of this paper.

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