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FLOWERING PHENOLOGY OF PINANG GAJAH (*Nenga gajah* J. DRANSF.) IN THE BOGOR BOTANIC GARDENS

FENOLOGI PEMBUNGAAN PINANG GAJAH (Nenga gajah J. Dransf.*) DI KEBUN RAYA BOGOR*

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Abstract

Nenga gajah J. Dransf. is an endemic palm species from Sumatra. The palm is one of the collections of the Bogor Botanic Gardens with seven collection numbers of *N. gajah* from Jambi and Riau. However, the reproduction information of the palm is still unknown until now. Information on the phenology of flowering is essential in conservation activities, especially its presence in nature and the production of seeds for reintroduction purposes. This study aims to determine the phases and timing of the flowering period and the factors that influence the flowering of *N. gajah* in the Bogor Botanic Gardens. This study was conducted on individuals at the phase of initiation of flowering. Flowering observation variables include the length of the period from flower buds to the anthesis phase until the flowers wither, and the fertilization process from young fruit to ripe. The flower and fruit of *N. gajah* were documented in each stage. The data recorded included flower and fruit development time for each phase and visiting insects. Data analysis was carried out descriptively to describe the process of flowering and fertilization that occurred. The results showed that the flower initiation phase took an average of 25.5 days, the anthesis phase took 6–7 days, the anthesis phase took 7–9 days, and the fruit formation and ripening phase took 100–120 days. Insects that are thought to act as pollinating insects for *N. gajah* include *Trigona* sp., *Polyrachis* sp., and *Apis* sp.

Keywords: Flowering; *Nenga gajah;* Phenology; Reproduction

Abstrak

Nenga gajah J. Dransf. *merupakan salah satu jenis palem endemik yang berasal dari Sumatra. Palem tersebut menjadi salah satu koleksi Kebun Raya Bogor dengan tujuh nomor koleksi N. gajah yang berasal dari Jambi dan Riau namun informasi reproduksi palem tersebut masih belum diketahui hingga kini. Informasi fenologi pembungaan tersebut sangat diperlukan dalam kegiatan konservasi, khususnya keberadaannya di alam dan produksi biji untuk tujuan reintroduksi. Penelitian ini bertujuan untuk mengetahui fase-fase dan waktu periode pembungaan dan mengetahui faktor-faktor yang memengaruhi pembungaan N. gajah di Kebun Raya Bogor. Penelitian ini dilakukan terhadap individu yang berada pada tahap inisiasi pembungaan. Variabel pengamatan pembungaan meliputi panjang periode dari kuncup bunga menuju fase antesis sampai bunga layu dan proses pembuahan dari buah muda sampai masak. Perkembangan bunga dan buah N. gajah didokumentasikan pada setiap fase, data yang dicatat meliputi waktu perkembangan bunga dan buah untuk setiap fase, serta serangga pengunjung. Analisis data dilakukan secara deskriptif untuk menggambarkan proses pembungaan dan pembuahan yang terjadi. Hasil pengamatan menunjukkan bahwa fase inisiasi bunga membutuhkan waktu rata-rata 25,5 hari, menuju fase antesis membutuhkan waktu 6–7 hari, fase antesis membutuhkan waktu 7–9 hari, dan fase pembentukan dan pematangan buah membutuhkan waktu 100–120 hari. Serangga yang diduga berperan sebagai serangga penyerbuk N. gajah antara lain Trigona* sp., *Polyrachis* sp., *dan Apis* sp.

Kata kunci*: Fenologi; Nenga gajah; Pembungaan; Reproduksi*

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INTRODUCTION

Indonesia is one of the largest palm diversity centers in the world. It is estimated that Indonesia has 46 genera out of 190 genera in the world, 29 of which are palm endemic genera (Govaerts & Dransfield, 2005).. According to Uhl and Dransfield (1987), Sumatra has 26 palm genera, including *Nenga* (Witono et al., 2004). The monoceous palm genus *Nenga* has five species: *Nenga banaensis* (Magalon) Burret, *Nenga gajah* J. Dransf, *Nenga grandiflora* Fernando, *Nenga macrocarpa* Scort. ex Becc., and *Nenga pumila* (Blume) H. Wendl (Fernando, 1983; Witono et al., 2004).

One species of palm endemic to Sumatra is *N. gajah* (Dransfield, 1975; Fernando, 1983). *Nenga gajah* known as *pinang gajah* have different morphological characteristics compared to other *Nenga* species because they have interfoliar inflorescences (between the leaf sheaths) while other species have infrafoliar inflorescences (under the canopy) (Fernando, 1983; Witono et al., 2004). Fernando (1983) explained that the palms are spread on the slopes of the *Dipterocarpaceae* forest up to an altitude of 800 meters above sea level. Based on the results of field surveys and herbarium collections at Herbarium Bogoriense, *N. gajah* were found in Bukit Tigapuluh National Park, Riau (Witono & Walters, 2000) and Bukit Duabelas National Park, Jambi (Astuti & Sutrisno, 2001). The collection of *N. gajah* from these 2 locations managed to grow and develop and even regenerate well in the Bogor Botanic Gardens (Ariati et al., 2019).

To support *ex-situ* conservation efforts in those Botanic gardens and *in-situ* in the natural habitat of *N. gajah*, it is necessary to conduct studies related to the phenology of their flowering. Flowering phenology is the study of the periods of phases that occur naturally in plants. These phases are strongly influenced by environmental factors such as the intensity of sunlight, temperature, and humidity (Fewless, 2006). This study aims to determine the phases, and the time of the flowering period, and to determine the factors that influence the flowering of *N. gajah*. This research is expected to provide important basic information about the *N. gajah* palm because each species of palm has different flowering patterns and characteristics.

MATERIALS AND METHODS

The study was conducted at the Bogor Botanic Gardens from January to May 2015. Observations were made at several locations, namely vak/plot XI.L, II.F, and the Nursery Building (Figure 1). The selection of samples was carried out on 8 individuals of *N. gajah* from two locations, namely Jambi and Riau (Table 1) which had been registered as collection plants, there were 7 individuals with 1 individual still in the nursery. The sampling process was carried out based on the criteria of individuals who are undergoing the initiation stage of flowering. Flowering observation variables include the flower initiation phase, phase to anthesis, anthesis phase to the process of fruit formation and ripening.

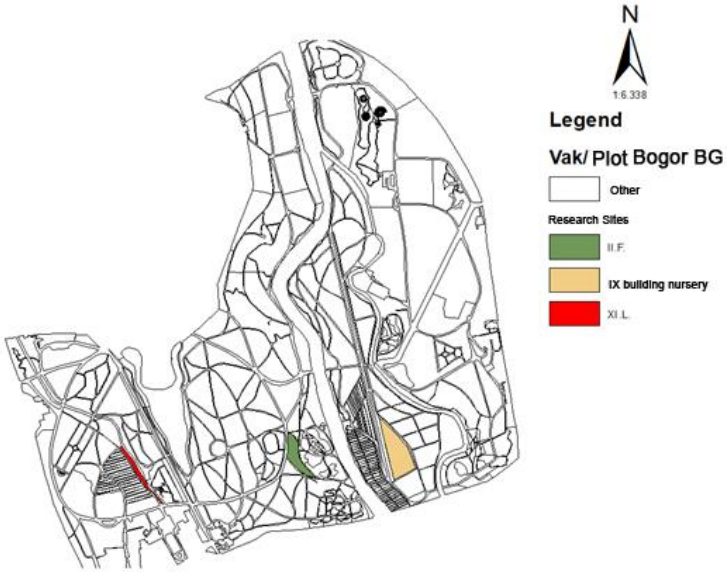

Figure 1. The location of the *Nenga gajah* phenology research in the Bogor Botanical Gardens

Table 1. *Nenga gajah* palm collection at Bogor Botanical Gardens

	Growing zone	Origin of collection
Nenga gajah	XI.L.64	Jambi
	XI.L.85	Jambi
	XI.L.85a	Jambi
	II.F.151	Jambi
	Nursery building Gd.IX	Jambi
	XI.L.62	Riau
	XI.L.62a	Riau
	XI.L.62b	Riau

Using a digital camera, every phase of *N. gajah*'s flower and fruit growth was recorded (Table 2). For each developmental period, the amount of time needed for flower and fruit development was also documented. To be identified, information about visiting insects is also recorded in the form of photographs.

Table 2. Observation of each phase of palm flowering phenology

The phenological phase of flowering	Description
Flower initiation	Phase of changes in flower morphology into reproductive buds
Pre-anthesis	Flowers begin to form differentiation of flower parts
Anthesis	Flowers bloom, and male and female flowers ripen
Formation of fruit	The development of a flower that succeeds in becoming a fruit/seed candidate, a flower that fails to be pollinated will be released from its rachilla
Ripening of fruit	Formation of ripe fruit, usually followed by drying of the tips of the rachilla

Source: Fitriani (2013); Yudaputra et al. (2016)

The data analysis used is descriptive analysis to describe the process of flowering and fertilization that occurs in the *N. gajah* palm. The descriptive data obtained were grouped based on the character of the shape, color, and size. Four-year rainfall data in the Bogor Botanic Gardens (2012–2015) was used to determine the effect of rainfall on the flowering phenology of *N. gajah* in the Bogor Botanic Gardens.

RESULTS

Nenga gajah Collection in the Bogor Botanical Gardens

The collection of *N. gajah* growing in the Bogor Botanic Gardens is now the result of exploration carried out in Sumatra in 2000 (Witono & Walters, 2000) and 2001 (Astuti & Sutrisno, 2001). The number of individuals of *N. gajah* that were alive and well developed were 7 collection numbers spread over several plots/vak (Table 1). Based on registration data of Bogor Botanic Gardens, the collection of *N. gajah* is known to have 2 collection numbers that died, namely collection numbers II.F.119 (died in 2000) and II.F.119a (died in 2016). These collections originated from Bengkulu in 1982. Witono et al. (2004) noted that the natural habitat of *N. gajah* grows on hillsides and the banks of small streams and is shaded. Therefore, the selection of the site where *N. gajah* grows in the Bogor Botanic Gardens is adjusted to conditions that are relatively similar to their natural habitat (Figure 2).

Dransfield (1975) revealed that the natural distribution of *N. gajah* found in Sumatra was at an altitude of 800–850 m asl, while the collection of *N. gajah* from Bukit Tigapuluh TN was at an altitude of 150 m asland Bukit Dua Belas NP was at an altitude of 180–240 m asl (Witono et al., 2004). This condition is not much different from the location where it grows in the Bogor Botanic Gardens which has an altitude of 285–300 m asl. Therefore, the growth of *N. gajah* outside its natural habitat showed a good growth trend with survival reaching 87.5%. Meanwhile, the distribution of 5 collections of *N. gajah* at the Ecopark Botanic Gardens, Cibinong Science Center

(CSC-LIPI) and Batam Botanic Gardens showed poor growth because all the specimens had died. Based on an interview with the manager of the Ecopark Botanic Gardens, the collection of *N. gajah* may have died due to the weather being too hot and the incorrect placement of the growing location because it was not in accordance with its natural habitat. The same thing also happened in the Batam Botanic Gardens where the collection of *N. gajah* was placed in a location where it did not support its survival so that it eventually died (personal communication).

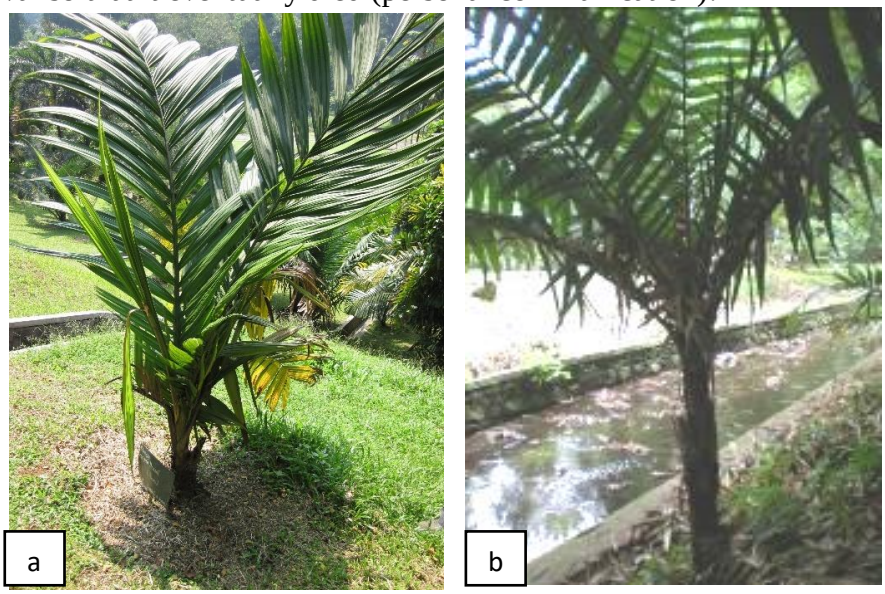

Figure 2. Living collection of *Nenga gajah* originating from Jambi (a) and living collection of *Nenga gajah* originating from Riau (b)

Flowering Phenology of *Nenga gajah*

The results showed that the flowering phenology of the collections of *N. gajah* from Jambi and Riau had the same characteristics and there was no difference. The flower arrangement of *N. gajah* is sympodial, forming 4 rachillas with interfoliar inflorescences (Figure 3). The prophyll of *N. gajah* is knife-shaped with toothed edges which are yellowish-green when young and turn gray-brown (Fig. 4a). This condition is part of the initial process of flowering, namely flower initiation.

The flower initiation phase of *N. gajah* begins with the appearance of a prophyll between the leaves (interfoliar). The next phase is the initial phase of anthesis which begins with the tearing of the prophyll accompanied by the appearance of 4 flower rachillas (Figure 4b). The flower of *N. gajah* is classified as a compound flower type because it consists of 4 rachillas consisting of male flowers and female flowers (Figure 3a; 3b). The number of rachillas *N. gajah* is much less compared to other palms such as *Areca vestiaria* which has 18–20 rachillas (Hanum & Lestari, 2017) and *Hydriastele beguinii* which has 15–18 rachillas (Yudaputra et al., 2017).

In detail, the initiation phase of *N. gajah* flowers takes an average of 25.5 days. Different conditions are shown by the initiation of *A. catechu* flowers which takes an average of 10 days, *A. vestiaria* takes about 7 days (Fitriani, 2013; Hanum & Lestari, 2017), and *Hydriastele beguinii* which takes an average of 7 days. 14 days (Yudaputra et al., 2017). The difference in flower initiation time required by *N. gajah* was longer than other palm collections. This may be due to the interfoliar type of flowering so that the appearance of the fruit sheath takes longer. This condition is different from the flowering type of infrafoliar palms where the prophyll appears after the leaf sheath falls off, such as the *Pinanga javana* (Zulkarnaen et al., 2019; Zulkarnaen et al., 2021).

The next phase of anthesis is that the male flowers bloom and fall off before the female flowers bloom (Figure 4c). The process of falling off the male flowers of *N. gajah* starts from the tip of the rachilla and dries up (Figure 4d). The time it takes for male flowers to fully bloom and fall, which is about 20–25 days. The process of changing color from yellow to dark purple (female flowers) which is rather striking occurs after the male flowers fall. The blooming of the female flowers at the end of the anthesis phase of the male flowers had all fallen off (Figure 4e). The

process of blooming female flowers begins less than 5–7 days after the male flowers fall. Female flowers last until fertilized by pollinators about 15–20 days until a prospective fruit will appear.

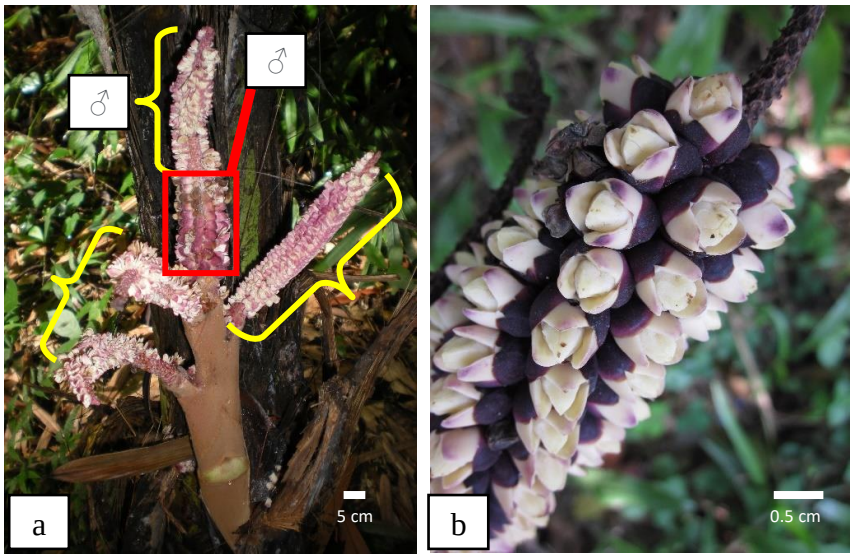

Figure 3. The initial condition of flowering consists of 4 rachillas with a composition of 3 rachillas containing male flowers (♂), 1 petiole containing a combination of male flowers (♂) and female flowers (♀) (a) and female flowers begin to bloom, but the male flowers have fallen off (b)

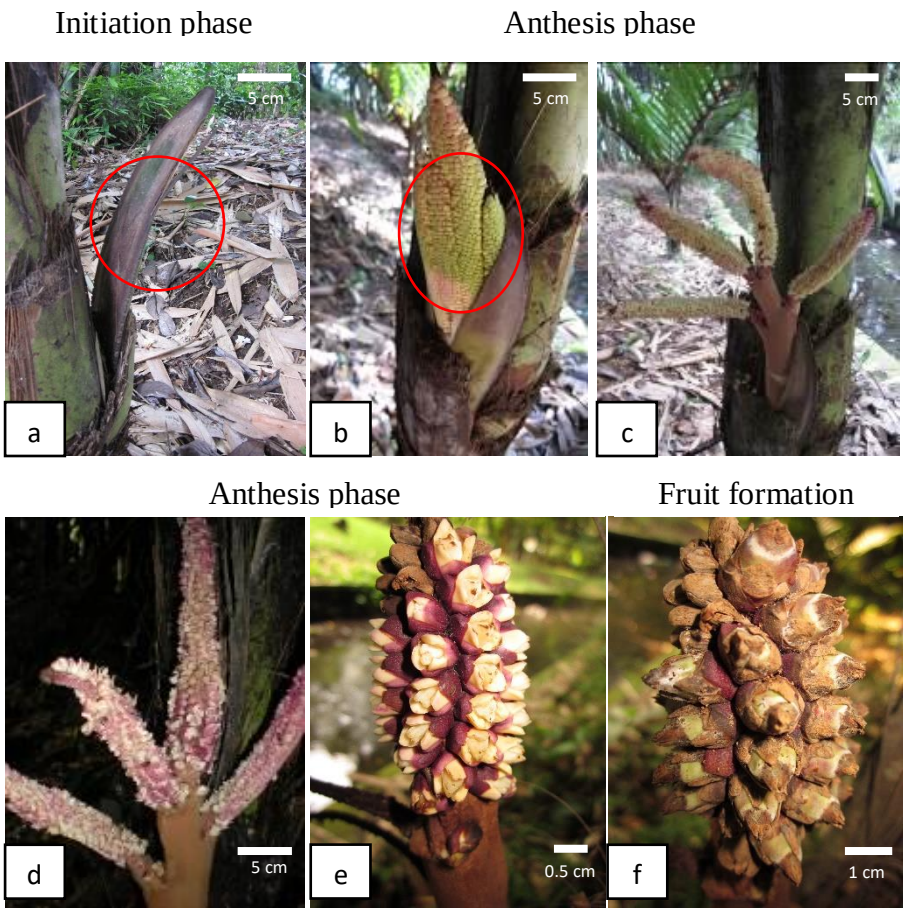

Figure 4. The inflorescence cycle of *N. gajah* in the Bogor Botanic Gardens, namely flower initiation begins with the appearance of a dark brown prophyll, the location is interfoliar, and shaped like a knife (a), anthesis begins with the tearing of the prophyll and the appearance of prophylls, male flowers bloom and fall off, then followed by the appearance of female flowers (b-e), and fruit formation begins with the emergence of ovules from female flowers and begins to enlarge (f)

Flower and Fruit Productivity of *Nenga gajah*

Generally, the appearance of male flowers and female flowers on palms (*Arecaceae*) has a different period, as well as the flowering of *N. gajah*. In the early flowering period (after the prophyll falls), it enters a phase towards anthesis where the male flowers appear first, then the male flowers fall and the female flowers appear. In the flowering of *N. gajah* usually from 4 rachillas formed, 2–3 rachillas are male flowers while others consist of female and male flowers.

The morphological characteristics of male flowers are creamy yellow, angular, oblong, and have an average size of 5 mm in length and 3 mm in width. The female flowers are purplish, round in shape, and have an average length of 7 mm and a width of 4–5 mm. The total number of male flowers is 200–300 flowers, while the female flowers are <200 flowers.

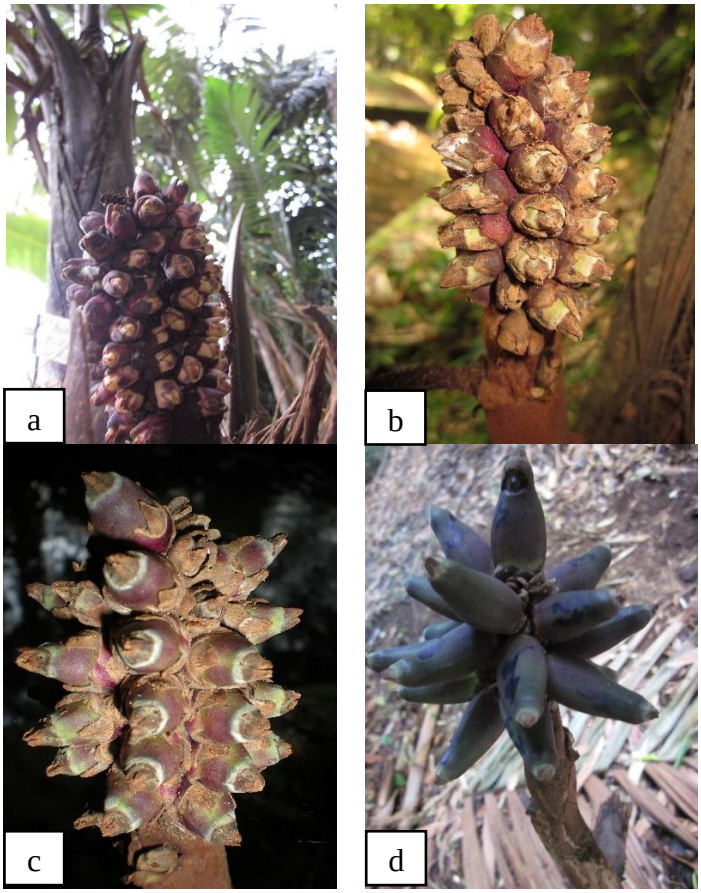

Figure 5. The development of the *Nenga gajah* fruit in the Bogor Botanic Gardens, namely the beginning of fertilization (a), the appearance of a green-white ovary (b), a change in the color of the fruit to purplish green and some of the fruit falling (c), and the ripe fruit being purple (d)

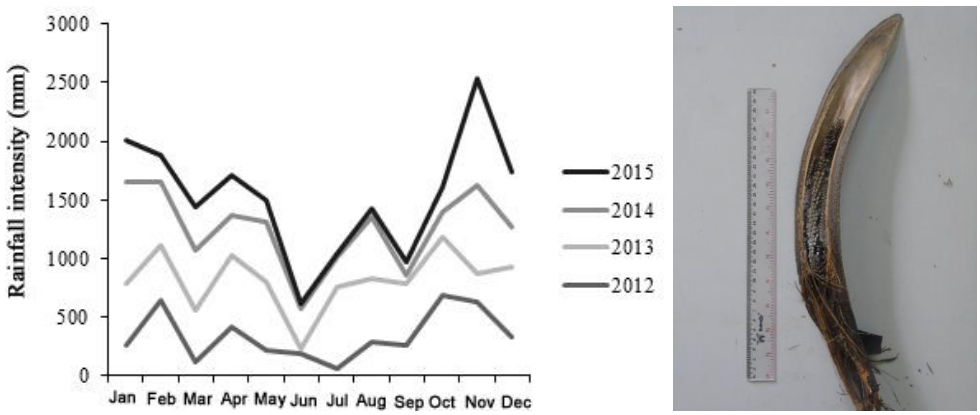

Figure 6. The intensity of rainfall and its effect on the prophyll. Rainfall intensity in Bogor Botanic Gardens from 2012–2017 (a) and prophyll rotting due to high rainfall intensity (b)

Based on data on flowering and fruiting of *N. gajah*, it shows that the percentage of success in becoming fruit is relatively small. Based on observations, the success of fruit production only occurred in one petiole with a percentage of about 15% (Figure 5a). This small value is thought to be due to the small percentage of female flowers and the inconsistent emergence period. In addition, this condition may occur due to several factors, one of which is the influence of the wind that knocks out male and female flowers. Fitriani (2013) also stated that the failure of pollination in *A. vestiaria* palm in the Bogor Botanic Gardens was not due to the ratio of male flowers to female flowers but due to natural factors (wind) and pollinating insect factors.

Figure 5a shows the beginning of fruit formation after the flower has been successfully fertilized with a number ranging from 60–70 prospective fruit ovules. This number decreases to 30–40 ovules (Figure 5b) and becomes 20–25 ovules (Figure 5c). Only 14–15 fruits were successfully formed (Figure 5d). The time it takes a female flower that is successfully fertilized until the fruit is ripe takes 100–120 days. This time is relatively faster than fruit formation in *A. vestiaria* palm which takes 308–319 days (Hanum & Lestari, 2017). Different conditions were also shown in the formation of *A. catechu* palm fruit which took 191–204 days (Yudaputra et al., 2016).

The results of observations of visitor insects found that there were three insects. These insects include *Trigona* sp. (Figure 7a), *Polyrachis* sp. (Figure 7b), and *Apis* sp. (Figure 7c). The three insects were thought to be pollinating insects on *N. gajah* flowers.

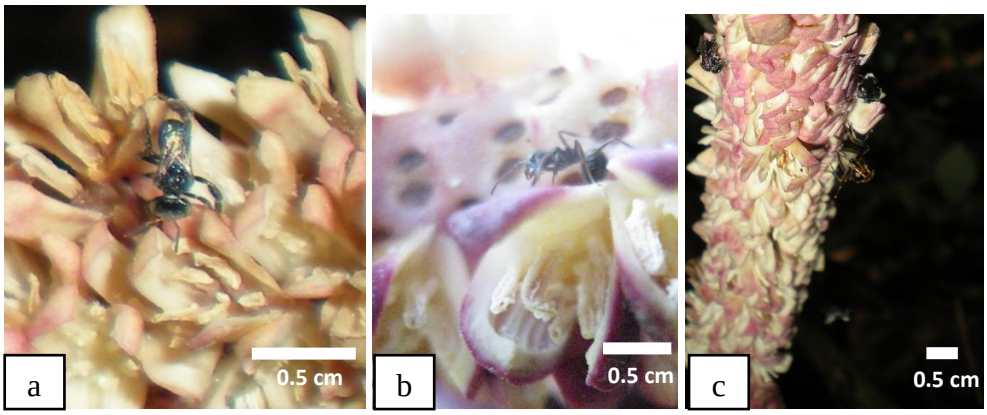

Figure 7. Visitor insects found in the flowering of *Nenga gajah*. *Trigona* sp. (a), black ant (*Polyrachis* sp.) (b), honey bee (*Apis* sp.) (c)

DISCUSSION

The flowering data of *N. gajah* is different from other palms and tends to have stable flowering. One example is *Hydriastele beguinii* which flowers and bears fruit regularly throughout the year (Yudaputra et al., 2017). The flowering of *N. gajah* in KRB from 2 different locations (Jambi and Riau) showed no significant difference and was relatively stable. This provides information that there is no influence of the origin of the collection on the variation of the flowering data that occurs. *N. gajah* is a species of palm that flowers and bears fruit throughout the year (pleonanthic), but the quality of flowers and fruit produced is strongly influenced by the season, especially rainfall.

The results of observations on the flowering of *N. gajah* indicate that the abiotic (environmental) factor that is thought to have an important role in the success of the flowering of *N. gajah* is the intensity of rainfall. The intensity of rainfall in the Bogor Botanic Gardens showed an increasing trend from 2012–2015 (Figure 6a). The data also shows that high rainfall intensity occurs from October to February. High rainfall causes failure in flower initiation because the fruit sheath is too moist and is attacked by fungi (Figure 6b). The percentage of successful flowering occurs in the dry or dry season between June and July. Decay does not only occur in the sheath but also occurs up to the rachilla (Figure 6b).

The flowering process of *N. gajah* is mostly formed in January to February but in that month the number of fruit formations is very small. This is probably due to the increasing rainfall so that many flowers fall out, while the high fruit formation process occurs from June to July. This is

probably due to low rainfall so that the percentage of flowers that fall is small and many flowers become fruit.

Yudaputra et al. (2017) revealed that the influence of environmental factors had an indirect influence on palm flowering. This is presumably because the reproduction process of palm flowering generally occurs after the natural leaf-shedding process without the influence of environmental factors. The intensity of rainfall is an important factor in the reproduction of flowering of dicotyledonous plant species (Darjanto & Satifah, 1990).

Another study stated that rainfall intensity is known to be a very important factor in the appearance of male and female flowers on several palms, for example, namely *Elaeis guineensis*/oil palm (Harahap & Lubis, 2018), *A. catechu* (Yudaputra et al., 2016), and *A. vestiaria* (Hanum & Lestari, 2017). Hartley (1977) revealed that the appearance of prophylls and male flowers on the *E. guineensis* palm was influenced by rainfall, while the female flowers were affected by solar radiation. Harahap and Lubis (2018) also added that fluctuations in the flowering productivity of *E. guineensis* are strongly determined by the dynamics of water in the formation of floral ornaments. The same thing also happened to the flowering conditions of the *A. vestiaria* which experienced a relatively longer period at less rainfall intensity compared to locations with high rainfall intensity (Hanum & Lestari, 2017).

Another factor that is thought to influence the flowering process of *N. gajah* is the arrival of pollinating insects which is strongly influenced by the presence of female flowers. The appearance of female *N. gajah* flowers in this study was only in 1 petiole so that fruit formation only occurred in one rachilla (Figure 3). This is one of the causes of the high percentage of failure of flowering of *N. gajah*.

Insects belonging to the *Trigona* and *Apis* genera are essential pollinators in the lowlands, including the habitat of palms (Corlett, 2004). Insects that visit the *N. gajah* palm are also relatively similar to the insects found in several other palm collections, such as *A. catechu* (Yudaputra et al., 2016), *A. vestiaria* (Hanum & Lestari, 2017), and *Hydriastele beguinii* (Yudaputra et al., 2017). Beetles (beetles) are also insect pollinators found in *N. gajah* palms in their natural habitat (Dransfield, 1975). In addition, beetle insects (*Nitidulidae*) are also mentioned as insects that are often associated with palm flowering in the Indomalayan region (Corlett, 2004). These insects are also found in several palms such as *Johannesteijsmannia* (Chan & Saw, 2012), *Salacca edulis* (Mogea, 1978), *Ceratolobus* (Dransfield, 1979), and *Plectocomia* (Madulid, 1980).

CONCLUSIONS AND SUGGESTIONS

There is no difference between the process of flowering, flower morphology, and fruit collection of *N. gajah* in the Bogor Botanic Botanic Gardens from Jambi and Riau. The phenology of flowering that occurs includes the initiation phase, leading to anthesis, anthesis, and fruit formation until ripe. Each phase has a different time, with a flowering period of about 38–40 days and fruit ripening to reach 100–120 days. Visitor insects found in the *N. gajah*, among others, *Trigona* sp., *Polyrachis* sp., and *Apis* sp. The abiotic factor which is strongly suspected to influence the success of the flowering of *N. gajah* is the intensity of rainfall.

Recommendations to increase the success of the phenology of flowering until the occurrence of fertilization requires human intervention. This is expected to increase the success of optimal fruit formation.

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