

Phenology of Flowering and Fruiting in Rukam Growth (*Flacourtia rukam* Zoll. & Moritzi)

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Abstract

Rukam is one of the fruiting plants that grow wild in the forest or are planted. Excessive utilization without cultivation efforts triggers a decrease in the population of a species in nature until a species disappears from nature. *Flacourtia rukam* has most recently been assessed for The IUCN Red List of Threatened Species in 2023. *Flacourtia rukam* is listed as Least Concern. Therefore, knowledge of flower and fruit development is needed to determine the effectiveness of production on rukam plants through phenological studies. This study was conducted to obtain information through morphological changes that occur and the length of time required during the flowering process to fruit formation on rukam. This research was conducted by directly observing and measuring the parts of the inflorescence from the process of fruit formation until the fruit ripening. The results showed that the morphological structure of rukam flowers is incomplete. The phenology of rukam flowering and fruiting takes 56 - 61 days starting with the flower initiation phase and ending with the mature fruit phase. The stages of morphological changes in flower development can be divided into initiation, small flower buds, large flower buds, and blooming flowers (anthesis). While the stages of morphological changes in fruit, color and size can be divided into young fruit, mature fruit, ripe fruit, and deciduous fruit. All stages of color change occur during the fruit ripening process.

Keywords: Phenology, fertilization flowering, rukam, morphology, local plants.

1. Introduction

Indonesia is one of the tropical countries that has various types of fruiting plants, ranging from planted fruiting plants to fruiting plants that grow wild in the forest. One of the fruiting plants that grow wild in the forest or planted is rukam (Solikin and Budiharta, 2010). Rukam is an edible wild fruit that can be consumed (Lim 2013; Nurtjahya et al., 2012). Rukam is a plant species that belongs to the Magnoliopsida class and the Flacourtiaceae family (Hesthiati et al., 2019). Rukam has short flowers, located in the leaf axils, yellow-green in color (Verheij & Coronel, 1991). Rukam fruit is round, hairless, with a diameter of 2-2.5 cm, green in color when the fruit is young and becomes purple or dark red when the fruit is ripe (Solikin and Budiharta, 2010).

According to (Deshmukh et al. 2011), the consumption of wild fruits is gradually decreasing due to the introduction of exotic fruits. Rukam is one of the local plant species found on Bangka Island. The habitat of rukam in the forest is found in the lowlands up to 2,100 m above sea level (Lim, 2013). Rukam has been used as a natural medicine to treat various diseases. For example, rukam leaves can be applied to treat inflamed eyelids, while a decoction of rukam roots is used by women after childbirth (Rana et al., 2018). Rukam is also used for diarrhea and dysentery (Coronel & Verheij, 1991). The part of rukam that

can be used as a diarrhea medicine is the leaf. The leaves used are young, brightly colored leaves. Rukam leaves contain alkaloid, flavonoid, phenolic and saponin compounds (Fitri *et al.*, 2016). Rukam also has the potential to treat eye worm disease (*thelaziasis*) in cattle (Supriadi and Janah, 2016).

(Rugayah *et al.*, 2017) stated that many plant species are becoming rare due to the fact that their place of growth has been converted into industrial areas, plantations, agriculture, road facilities, transportation, and settlements. (Kusumo *et al.*, 2002) stated that among the many types of fruiting plants are now starting to not be found or have begun to be rare. This is caused by changes in the condition of biological resources, land, and habitat due to uncontrolled utilization. Excessive utilization without cultivation efforts will also increasingly trigger a decline in the population of a species in nature until a species disappears from nature. Therefore, knowledge of flower and fruit development is needed to determine the effectiveness of production on rukam plants through phenological studies. The phenology of flowering and fruiting in rukam plants needs to be studied further in order to obtain information on changes that occur during flowering and fruiting. Population declines can be attributed to a mismatch between flowering time and the availability of pollinators or environmental conditions required for reproduction. Changes in environmental conditions due to climate change cause disruption in plant growth and development, leading to a decrease in fruit and flower production and quality (Adhya *et al.*, 2024). In addition, climate change can also trigger shifts in response, morphology and phenology of plants (Pulatov *et al.*, 2015; Sarvina, 2019).

Phenology is known to be widely used to calendar the growth and development of a plant, especially for plants that are already rare or have low viability (Barlian *et al.*, 1998). The phases of flowering and fertilization that occur naturally in plants can be known from the plant's life cycle. According to (Sitompul & Guritno, 1995) observations of plant phenology are often done is the change of vegetative period to generative and generative period length of the plant. This is usually done through the approach of observing the age of flowers, seed formation, and harvest.

Research related to the phenological phase of rukam has never been reported and is still very limited. Information on the phenology of flowering and fertilization of rukam is important for the preservation of these plants because they have a rare status in their natural habitat. Therefore, research on the phenology of fertilization and flowering of rukam needs to be carried out in order to obtain information through morphological changes that occur in these plant parts.

2. Material and Method

2.1 Material

Time and Place

This study was conducted from November 2022 to January 2023, in the yards of residents in Kuday Village, Sungailiat District, Bangka Regency, Bangka Belitung Islands Province. The research was conducted every day in the morning at 08.00 WIB and in the

afternoon at 16.00 WIB. This is because temperature and humidity tend to be more stable in the morning and evening compared to the heat of the day. This minimizes stress on the plants and allows for more accurate observation of their physiological condition.

Tools and Materials

The tools that will be used in this study are stationery, labels, ruler, vernier, cellphone camera, GPS (*Global Positioning System*), *lux meter*, *soil tester*, and *thermohygrometer*. Materials that will be used are samples of rukam flowers and fruits in the research location.

2.2 Method

Preliminary Survey

The preliminary survey was conducted directly in the yard of a resident's house in Kuday Village, Sungailiat District, Bangka Regency, Bangka Belitung Islands Province. The preliminary survey was carried out with the aim of knowing the condition of the location at the time of the research, as well as seeing the growth of rukam that allows for observation and data collection. The data used in this observation is primary data generated by researchers from direct measurement and observation at the research site.

Sample Selection Conditions

Flowering and fruiting phenology was observed directly on 1 rukam tree. With one sample, environmental variables and growth conditions can be more easily controlled and measured, so one sample is considered representative for the study. The number of flowers to be observed is 20 flower samples, the observed flower samples are marked (labeled). Observations of flowering phenology were made every day to see the changes. Each number of flowers was counted at the beginning of the observation until the last observation.

Observations and Measurements of Flowering and Fertilization Phases

Observations on flowering phenology can be seen in the limitation of flower stadia. Flower development stadia are based on the criteria used by (Dafni, 1993) with some modifications, namely: initiation stadia, small bud stadia, large bud stadia, open flower stadia, and fruit development stadia. It is necessary to limit each phase of the flower to be observed to facilitate observation. The limitations of each stadia are described in table 1 and table 2. Each stadia is observed for changes in color and shape as well as flower morphology. Observations were made every day by directly observing the development of rukam flowers and fruits. The process of flower and fruit development was then photographed and analyzed to determine the stages of development.

Qualitative Observations

Qualitative data collection observed stages and color changes in flowers and fruits, fruit color and shape, petal shape, and flower and fruit morphology.

Quantitative Observations

Quantitative data collection observed included measures related to the development of rukam flowers and fruits, as well as the duration of vegetative and generative stadia.

Table 1. Fruit Development Phase Observation Results.

Phase	Symbol	Description
Young Fruit	F4	Small light green fruits start to appear, the flesh is firm, and the flavor is astringent.
Mature Fruit	F5	The increase in size and change in fruit color from light green to yellowish red, the texture of the fruit flesh begins to soften, and still has a strong astringent sour taste.
Ripe Fruit	F6	There is an obvious color change to dark red or purplish red, the texture of the pulp is soft and contains a lot of water, and has a sweet taste.
Fall Fruit	F7	The skin surface is slightly rough and slightly wrinkled, purple-black or brown-black in color, and has a astringent and bland taste.

Measurement of Environmental Factors

Measurement of environmental factors is carried out at the observation point where the rukam grows. environmental factors that support the process of flower development, the aim is to know the weather conditions during the flower development period. Determination of the coordinate location point of the study was determined using GPS (*Global Positioning System*). Other abiotic data to be measured are soil temperature, soil pH, light intensity, air temperature and humidity. Abiotic data measurements are carried out every day in the morning at 08.00 WIB and in the afternoon at 16.00 WIB.

Data Analysis

Observation data obtained were presented in tabulated tables and analyzed. Data analysis was carried out descriptively. In addition, research data using quantitative methods, to explore the results that have been obtained through measurements and then analyzed using descriptive statistics, including vegetative and generative morphological characters (flowers) of rukam plants. The data analyzed aims to describe in detail and systematically starting from the flower initiation phase to the fertilization phase.

3. Results and Discussion

3.1 Results

Based on the research conducted, the following results were obtained.



Figure 1. Flowering process of Rukam; flower initiation phase (1), small bud phase (2), large bud phase (3), flower bloom phase (4), flower fall phase (5).



Figure 2. Flowering process of Rukam; young fruit (a), mature fruit (b), ripe fruit (c).

3.2 Discussion

Stages of Rukam Flower and Fruit Development

The observation period of rukam starts from the appearance of flower buds (initiation stage) to fruit maturity. The stages of development of rukam flowers and fruits starting from the initiation stage until the fruit falls off require a total of 56 - 61 days. The development of rukam flowers goes through 4 stages including initiation (*F0*), small buds (*F1*), large buds (*F3*), and open flowers (*F3*).

The initiation phase (*F0*) is the initial stage of observation of flowering on rukam which is characterized by the appearance of clusters in the form of flower bud protrusions that are so small that it is not yet clearly visible part of the flower stalk with other flowers, greenish white in color found on the stem branches and in the leaf axils. The shortest size of this phase is 0.01 mm, the end of this phase is characterized by an increase in the length of the bud stalk of 0.1 cm, and requires a period of 7 days. The next stage enters the small bud phase (*F1*) which is a continuation of the initiation phase (*F0*).

Flower development after the initiation phase then continues with small flower buds that continue to enlarge with a stalk length of 0.1 cm - 0.3 cm. The increase in bud size indicates that the flower buds are showing growth and development (Damaiyani & Metusala, 2011). This phase is also characterized by the appearance of the tip of the bud as it begins to split. The small flower bud phase (*F1*) has a period of 5 days to go to the large flower bud phase (*F2*). A decrease in the success of rukam fruit production can occur due to flower and fruit loss from flower formation to fruit development. Both phases (*F0*) and (*F1*) are prone to shedding. According to (Nurtjahjaningsih et al., 2012), basically the flowering process is an interaction of the influence of external factors, namely temperature, light, humidity, rainfall, and nutrients as well as internal factors, namely genetics and hormones. Changes in the environment can change the flowering response in plants (Darjanto & Satifah, 1990).

The large bud phase (*F2*) is a stage that is almost similar to the previous phase (*F1*). The large flower bud phase (*F2*) is characterized by changes in the bud slightly enlarged like swelling, and the length of the bud stalk also increases from the previous phase (*F1*), the petals have also begun to show their growth. The petals in this phase have begun to form and look whitish light green in color which is not too bright. This phase also experienced an increase in stalk length of 0.3 cm - 0.4 cm and bud length of 0.2 cm - 0.3 cm which lasted for 6 days. Based on observations, rukam flowers do not have a crown, this is in accordance with the statement of (Desitarani et al., 2014) which says that flowers on rukam do not have a crown. However, the pistil which is an important part of the flower is still protected by petals that have not fully bloomed. Each plant species has a different response to the environment for flowering (Thomas, 1993).

The next phase is the flower blossom phase (anthesis). This phase is the stage when flower expansion occurs (flower blooms completely). The anthesis phase (*F3*) occurs after the big bud phase ends until there is no more flower growth and continues until entering the fruit phase until the fruit ripens. The anthesis phase on rukam lasts for 9 days with an increase in stalk length of 0.4 cm - 0.6 cm. Macroscopically the parts of the flower are clearly visible. The anthesis phase (*F3*) occurs simultaneously with the maturity of reproductive organs in rukam flowers.

(Sedgley & Griffin, 1989) stated that in general, the length of time between the stages of flower initiation and blooming varies because it is influenced by the growth pattern, temperature range and humidity where a plant species grows. The process of fruit development begins on the 28th day. The visible characteristics of this phase are the appearance of small light green fruits, hard fruit flesh and no aroma, and a astringent taste. The stage of fruit emergence measures 0.3 cm - 1.1 cm in length and 0.7 cm - 1.3 cm in diameter. The young fruit phase lasts for 10 days and in this phase the fruit will continue to increase in size.

The development of mature fruit (*F5*) takes 5 days which is also characterized by an increase in fruit length of 1.1 cm - 1.6 cm with a fruit diameter of 1.3 cm - 2.3 cm. Mature

rukam fruits show changes in characteristics such as the fruit changing color from green to yellowish red or sometimes pink with a smooth surface of the fruit skin and the texture of the fruit flesh which begins to soften and is slightly watery. (Sedgley & Griffin, 1989) stated that water loss and drying occur at the end of the fruit development process which indicates the destruction of chlorophyll. The flavor of the rukam fruit in this phase also undergoes changes such as a tart taste that is still very concentrated with very little sweetness. (Giovannoni, 2001) states that ethylene plays a role in physiological and biochemical changes that occur during fruit ripening. The moisture content of the fruit is an indicator of fruit maturity.

Ripe fruit development (*F6*) lasts for 14 days after passing the mature fruit phase. The formed rukam fruit will slowly continue to grow until it reaches a size of 2.5 cm in diameter with a purplish red color. Rukam fruits that have the color and size previously experienced changes from day to day ranging from light green, pink, red, until finally turning into a dark red or purplish red color. An increase in temperature can affect the rapid maturity of the fruit. In general, the decrease in water content in fruit is influenced by physiological activity (respiration) and environmental conditions (transpiration) (Agusta & Ahmad, 2016). In addition to visible changes in color and size, the surface of the rind of ripe rukam fruit is shinier and smoother, the water content is more and the acid taste contained is also not too significant from the previous phase. This fruit can be enjoyed and said to be sweet if before consumption first by massaging the fruit because bruising the fruit flesh can eliminate the astringent taste contained therein.

The process of fruit drop lasts for 5 days, in this phase the length of the fruit is < 2 cm - fruit drop and the diameter is < 2.5 cm - fruit drop, has a astringent and tasteless taste, and is purple-black in color. Environmental factors also influence fruit drop. In the natural process of fruit drop, fruits fall as part of the plant's efforts to maintain harmony, resilience or physical strength in its growth. This kind of abortion is often found in various types or varieties of fruits in the tropics and subtropics.

Conclusion

Based on the results of research on the phenology of flowering and fertilization of rukam, it can be concluded that in the morphological structure of rukam flowers are incomplete flowers. The stages of morphological changes in flower development can be divided into initiation, small flower buds, large flower buds, and blooming flowers (anthesis). Based on changes in fruit morphology, color and size can be divided into young fruit, mature fruit, ripe fruit, and deciduous fruit. All stages undergo color changes during the fruit ripening process.

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