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Short Communication: The phenology of *Sonneratia alba* J. Smith in Berbak and Sembilang National Park, South Sumatra, Indonesia

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Abstract. *Sarno, Suwignyo RA, Dahlan Z, Munandar, Ridho MR, Aminasih N, Harmida, Armanto ME, Wildayana E. 2017. Short Communication: The phenology of* Sonneratia alba *J. Smith in Berbak and Sembilang National Park, South Sumatra, Indonesia. Biodiversitas 18: 909-915.* The ecosystem of mangrove forms the largest portion of the habitat in Berbak and Sembilang National Park (BSNP), Banyuasin District, South Sumatra Province, Indonesia, which is the largest mangrove area in the western part of Indonesia. There is a tendency that the mangrove condition in this area is gradually degrading over time. The main causes of mangrove destructions are both natural and human factors. The destructions of mangrove in BSNP directed by human are more than natural factors, for axample, land use conversion from wildland into cultivated land, the making of ponds, especially along Banyuasin Peninsula. The information on the observation of mangrove phenology is very important for sustainable mangrove management. The observation of mangrove phenology in the restoration area of BSNP is intended to study the natural stages of growth and reproductive development of *Sonneratia alba* J. Smith, the local name is Padada. The observation is done by means of tagging methods. Monitoring is conducted periodically from the flowering time until the fruit was ripe. The phenology of Sonneratia alba takes about three months from the beginning of flowering until the fruit was ripe.

Keywords: Climate, conservation, mangrove, phenology, *Sonneratia alba*

INTRODUCTION

Mangrove is defined as a plant species or a type of tree as well as a type of forest that grows in the muddy land of tidal areas, along a coastal areas with shallow waters and along the rivers and creeks of brackish water (Tomlinson 1994; Nagarajan et al. 2007). The existence of mangrove ecosystems is very important because mangroves play apart in economic and ecological functions. The economics function of mangroves are as the building substance made from woods, various household materials and medications. Nevertheless, the ecological functions of mangroves are as the spawning sites for fish and as a natural stands to protect the human settlements from the strong wind and sea water intrusion, including tsunami catastrophe (Onrizal et al. 2009, 2017; Onrizal and Manzor 2016).

The studies of mangrove phenology provides information about the time and duration of the reproductive stage of plants which includes the information of buds, flowering, fruiting and seed germination. *S. alba* is one of the true mangroves species with an uncompleted phenological information (Wang'ondu et al. 2013).

It is crucial to study the phenology of *S. alba* or also known as padada by the locals to provide the details regarding the time of its regeneration. Hence, by referring to the information provided, one can estimate the success rate of replanting the mangrove for both reasons: natural disasters and convertion of forest area utilization.

Sonneratia alba is one type of mangrove with rapid development, starting from the development of buds, flowers that become the fruit that is ready to become a new seedling. The phenology of *S. alba* in the country of Vietnam, from flowering to fruiting, usually occurs within 3-4 months (Duke 2012). The result of phenological observations of *S. alba* at Gazi Bay, Kenya showed that the phenology of *S. alba* occurred within 4-5 months (Wang'ondu et al. 2013). *S. alba* is classified as true mangrove species due to their ability to form pure stands, characterizing the community structure of mangrove, morphologically has specialized adaptive forms and has a physiological mechanism in terms of controlling salt (Tomlinson 1994).

The study was conducted to reveal the flowering time and the floral characteristics of *S. alba*; the time needed by the plant to bear a flower, fruit and the time for it to become ripe. Therefor, the benefit of this study is to provide scientific information regarding the time of flowering until the time of fruit ripening and the characteristics of the flower and the fruit of *S. alba*.

MATERIALS AND METHODS

Study area

The phenological observation was carried out in July 2016 until October 2016. The location of sampling site was located in Barong Kecil in the Sembilang National Park (SNP) formed of Berbak and Sembilang National Park (BSNP) South Sumatra (Figure 1). The result for the pH in the sampling site of the parent tree showed a value of 6-7. The higher acidity was indicated by the low value of pH. The pH values also affect the availability of nutrients for the plants. The temperature recorded ranges from 29 to 30 ^{o}C and the values are classified as normal and optimal for mangrove development.

The secondary data for climate were obtained from the Indonesian Agency for Meteorology, Climatology and Geophysics station in Kenten Sako, Palembang, South Sumatra. The stage of mangrove breeding or phenology is very closely related with the conditions in the field. The environmental factors such as the rainfall, the temperature and the wind affect phenological process. The climate data in the study areas globally cover the elements of the climate, the number of rainy days and the precipitation in the region of Palembang in South Sumatra, are presented in Figure 2.

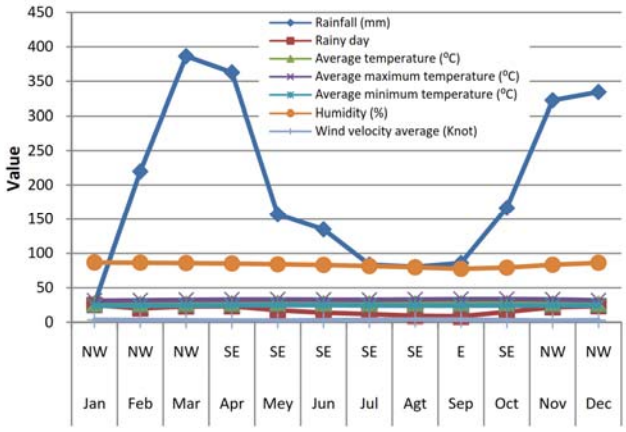

Figure 2. The elements of the climate in the study area (Modified data from Indonesian Agency for Meteorology, Climatology and Geophysics station in Kenten Sako, Palembang, South Sumatra 2016)

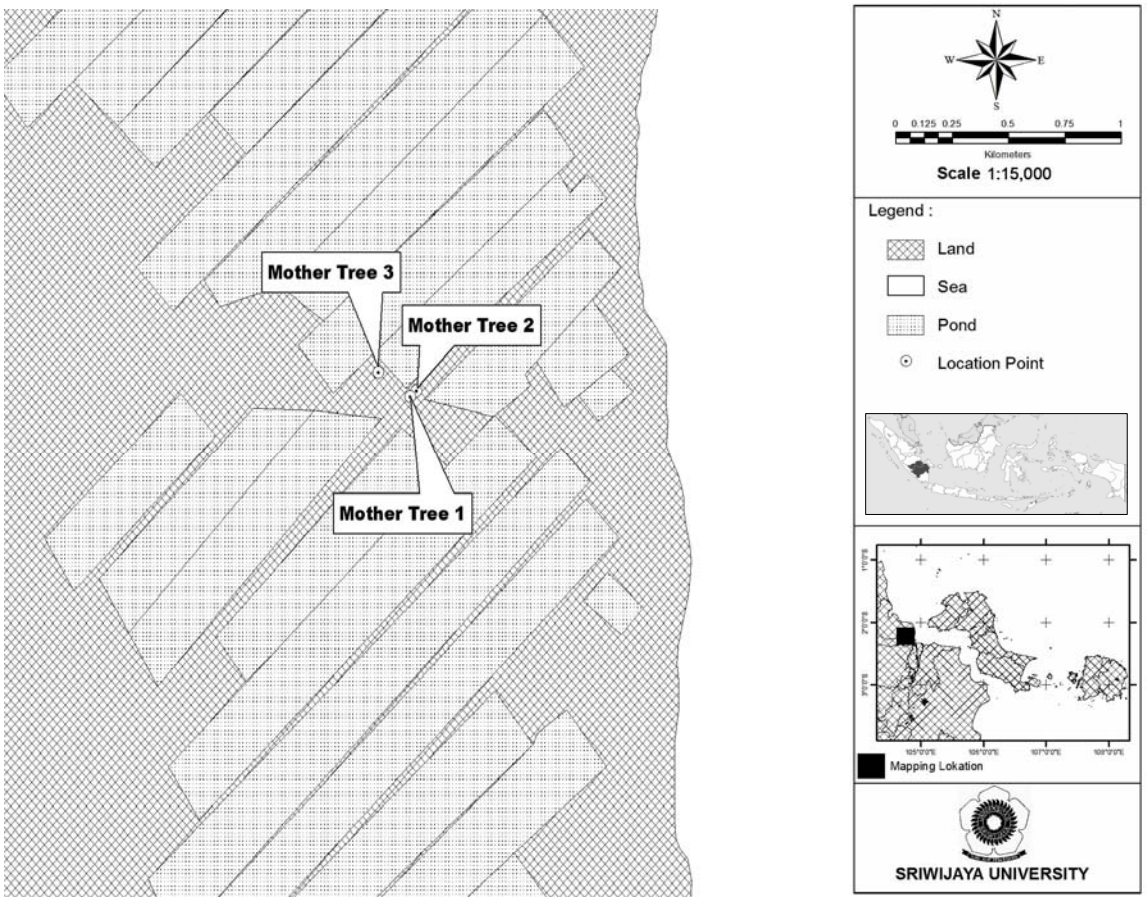

Figure 1. The location of phenological observation of *S. alba* in the Berbak and Sembilang National Park (BSNP), South Sumatra, Indonesia. The coordinate points of the location of the *S. alba* trees are as follows: mother tree 1is located at the coordinate points of S 02^{o}09.744' E 104^{o}53.678'; mother tree 2 is located at the coordinate points of S 02^{o}09.718' E 104^{o}53.710'; and mother tree 3 is located at the coordinate points of S 02^{o}09.660' E 104^{o}53.622'

The activity of installing has the main cause of mangroves degradation in Banyuasin Peninsula, BSNP, South Sumatra since 1995 (Ulqodry et al. 2010; Suwignyo et al. 2012; Munandar et al. 2014; Sarno et al. 2015). Mangrove forests are extremely important coastal resources, which are vital to our development (Tomlison 1986; Goudkamp and June 2006; Ghost 2011). Mangrove is one of the most threatened ecosystems all over the world today due to direct and indirect degradation (Duke et al. 2007; Kathiresan et al. 2010; Donato et al. 2011), including in Indonesia (Ilman et al. 2016)

Procedures

The initial field survey was conducted to determine the mother trees and phenological observations of *S. alba* in the area of BSNP, Banyuasin Peninsula. The determination of the mother trees was done at three of *S. alba*. The mother trees selected were the trees that have entered the stage of initiation of flowering. The sampling was done by means of purposive sampling. The selected samples were marked or tagging with a tape to facilitate the observation. The observation of flowering stage of *S. alba* was conducted starting from flower initiation stage, small buds, big buds and blooming flowers. Furthermore, the calculation of the time span of each flowering stage and the shooting for the documentation was conducted. The morphological observation covers the shapes, the sizes, and the colors. The observation stage of fertilization of *S. alba* was conducted starting from young fruit to ripe fruit.

Data analysis

The phenological stages of *S. alba* starting from the flowering stage until the fruit is ripe are presented in the form of figures and then analyzed descriptively.

RESULTS AND DISCUSSION

Roots of *Sonneratia alba*

Based on the field observations that have been carried out, the morphological characteristics of *S. alba* are described as follows. The roots of *S. alba* are classified as breathing root group, standing upright and has a conical shape. The roots of *S. alba* appear vertically on the surface of the soil. The color of *S. alba*'s roots is light brown to dark brown. At the pencil roots, there are pneumatophores (Duke and Schmitt 2015) or gaps for air impress, so that oxygen can get into the soil that does not contains oxygen. The height of *S. alba*'s roots ranges from 5.0 to 12.5 cm and the diameter ranges from 1.0 to 1.5 cm (Figure 3). The characteristics of *S. alba* that was chosen to be a mother tree as shown in Table 1.

Habitus *S. alba* is a tree with a height of 7-10 m. *S. alba* tree has a trunk of grayish brown, with rough cracks in its bark, round-shaped and has a trunk circumference of 30-35 cm. The habitus *S. alba* is a large tree, the bark of which is light gray in color and the surface texture of the trunk is cracked.

Table 1. The characteristics of a *Sonneratia alba*'s mother tree

Parameters	Mother tree			Average
	1	2	3	
Height of trunk	7 m	80 m	10 m	8.3 m
Circumstance of trunk	33 cm	30 cm	35 cm	32.7 cm
Height of root	5 cm	10.5 cm	12.5 cm	9.3 cm
Lenght of leaf	10 cm	9 cm	10 cm	9.7 cm
Width of leaf	4.5 cm	3.5 cm	5 cm	4.3 cm
Length of ripe fruit	2.5 cm	3 cm	3 cm	2.8 cm
Width of ripe fruit	4.5 cm	5 cm	5.5 cm	5 cm

Leaf of *Sonneratia alba*

The leaf of *S. alba* is a single leaf, the young leaf is light green slightly yellowish and old leaf is dark green. The upper surface of the leaf has a smooth texture. *S. alba* has leaf venation of penninerved and green in color. The shape of the leaf is round with no angles at all. The shape of leaf base in blunt, with rounded leaf tips and edges of leaves, are flat (Figure 3).

Flowers of *Sonneratia alba*

The flower of *S. alba* is a perfect flower. The flower is located at the end of twigs, with a number of one to 3 per group. Flowers of *S. alba* have six petal strands. The outside part of the petal is green, while the inside part of the flower is a pink color. The shape of the flower base is like a cup and the pistils of the flower are in the middle of the flower base. The corolla of the flowers is creamy white, barely visible because it is located among the petals and is similar to stamens, numbering 6 strands. The stamens are numerous, white in color surrounding the pistil. The pistil is one and is in the center of the flower. According to Raju et al. (2013), the position of the ovary of *S. alba* flower is at the base of the flower. The yarn-shaped stylus undergoes elongation beyond the length of the stamens and ended with the emergence of the stigma (Figure 3).

The flower of *S. alba* has 6 strands of petals, 6 strands of the corolla, one strand of the pistil, numerous stamens, and superuser ovary. It is written in the flower formula as K (6)C6A∞G1 and illustrated in the diagram in Figure 4. The number of K is varied, it can be 5-8 (Kitamura et al. 1997) or 6-7 (Ragavan et al. 2014).

Discussion

Generally, *S. alba* has the same characteristics despite growing in different areas. Differences in the shape and size of vegetative parts caused by environmental factors. According to Souza et al. (2014) and Farooqui and Siddiqui (2014), reproductive phenology is strongly influenced by environmental factors. According to Coupland et al. (2005), *S. alba* able to take advantage from the available natural pollinator. *S. alba* is a pioneer species (Kathiresan et al. 2010) and were committing occur throuhgout the year (Duke and Schmitt 2015). Is likely to be different for each year (Landry 2013). The stage of reproductive development in plants is started with the stage of the flowering initiation, small bud, big bud and blooming flowers and which is then followed by the development of fruit, namely young fruit and ripe fruit.

Figure 3. The morphology of *Sonneratia alba.* A. Root, B. Leaf, C. Flower, D. Fruit

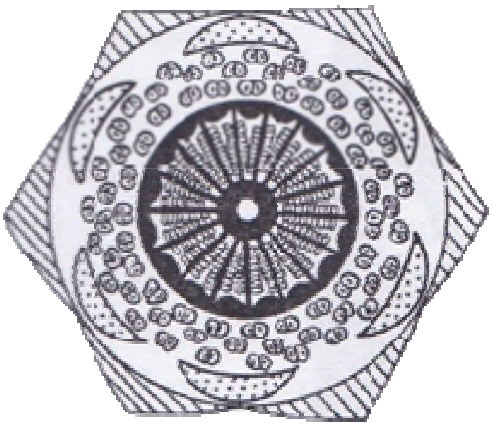

Figure 4. The flower diagram of *Sonneratia alba* (modified from Tomlinson 1994)

The initiation of the flower is a morphological change stage from vegetative buds to reproductive buds which is marked by the emergence of the bud on the prospective flower stalk. The color of the bud is light green, its shape is round protrusion with a size of 0.5 cm (Figure 5.A). The phase of the small bud is defined as a measurement of reproductive bud marked with a round bud with the tapered edge, reddish green in color with a size of 0.8 cm (B). The bud is green with a slight reddish line with size 1.2 cm (C). According to Figure 6, the green bud grows with blunt end with the size of 2.7 cm (A). The light green buds are found in various sizes of 2.9 cm (B), 3.0 cm (C) and 3.6 cm (D).

The big buds are marked with flower petals beginning to open from the end of the buds and the white stamens are shown with a size of 4.5 cm (A). The petals open, reddish in color on the inner side of the petals, the stamens are still rolled on the pistil with a size of 4.6 cm (B). The blooming flowers are characterized by open petals and also stamens. The petals are green, the stamens are white and the anther is yellowish in color. According to Teo (2013), '*alba'* means white in Latin which refers to the distinctive white stamens. A completely blooming flower, the petals and stamens are opened with a size of 6.1 cm (D). The flowers begin to wilt, characterized by the stamens which start falling and the pollination by insects occurs. The flowers wither, marked by the collapse of the stamens from the flower base. The pistil withers, characterized by the changing color from green to amber. The ovary begins to be visible from the flower base and the pistils become dry and shriveled to be a size of 4.7 cm (H). The ovary grows in size, the pistil dries and withers. The young fruit is green, slightly rough in texture and the pistil dries with a size of 4.8 cm (I) (Figure 7).

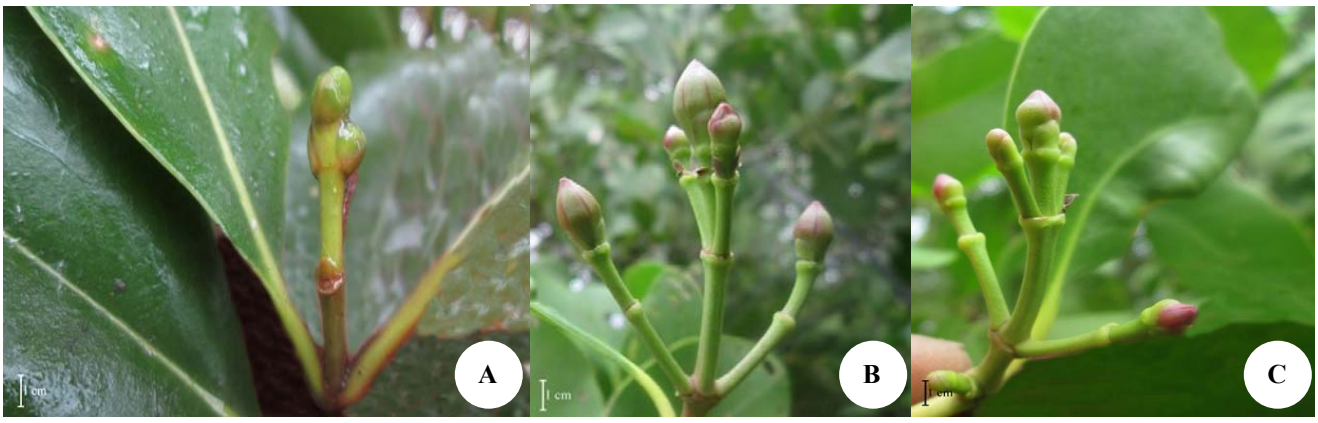

Figure 5. The initiation flowering of *Sonneratia alba* in July 2016 (from left to right)

Figure 6. The development of *Sonneratia alba*'s flowering shoot in August 2016 (from left to right)

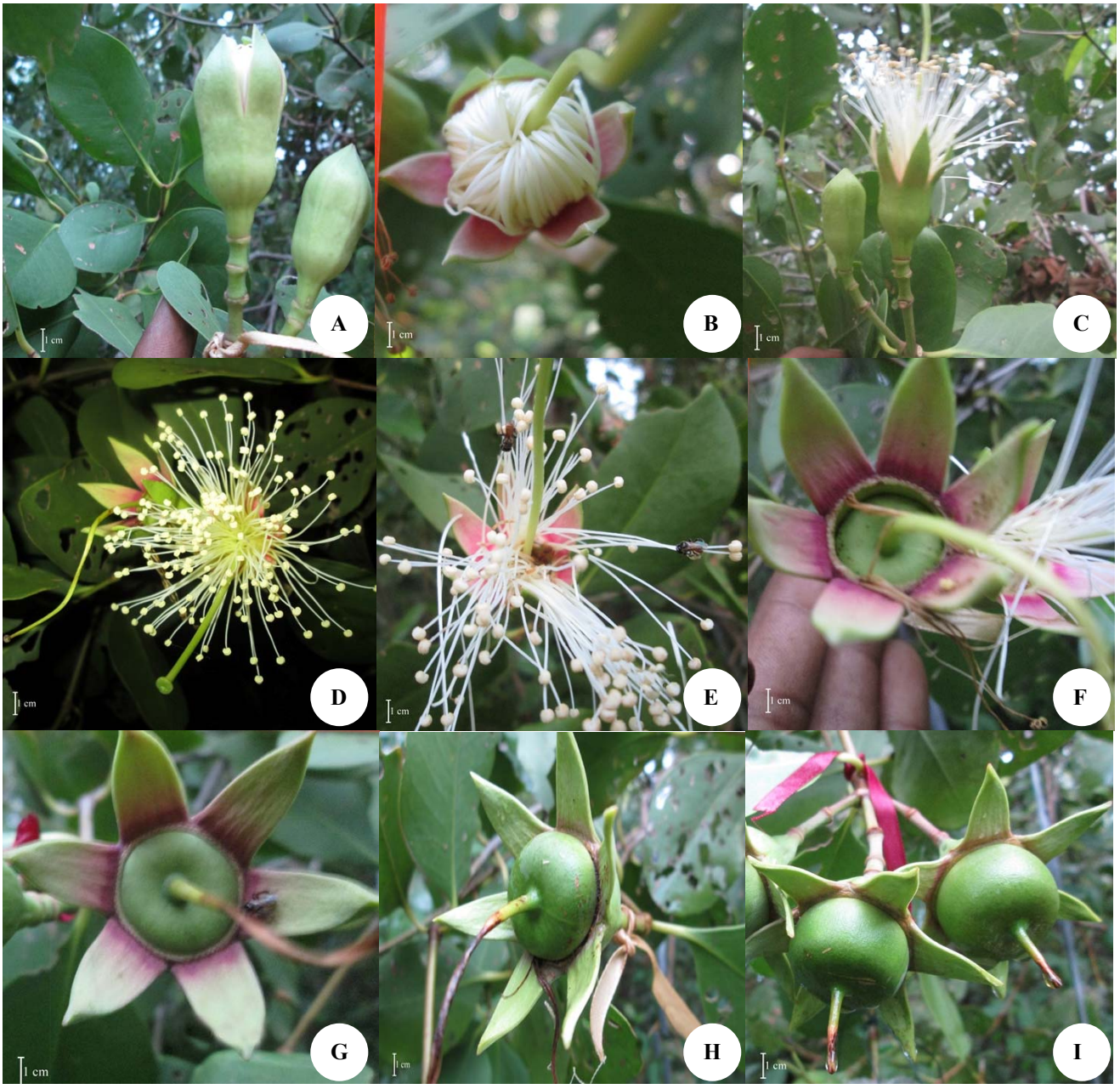

Figure 7. The development fruit of *Sonneratia alba* in September 2016 (from A to I)

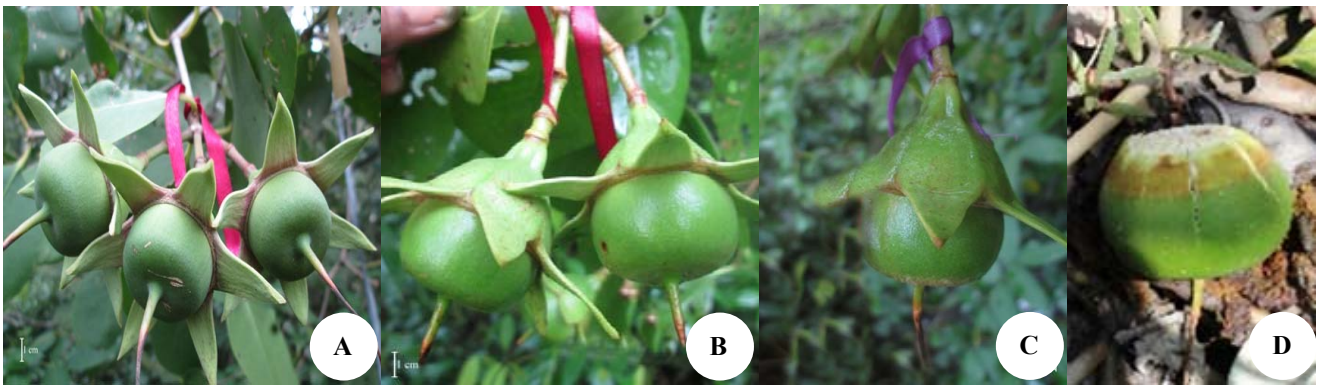

Figure 8. The ripening fruit of *Sonneratia alba* in October 2016 (from left to right)

The young fruit has grown in size to become round in shape with a size of 4.9 cm (Figure 8.A). The young fruit is green and grows in size of 5.0 cm (B). The young fruit is green in color, pistil withers and dries with a size of 5.5 cm (C). The ripe fruit is green (C) and characterized by a cracked fruit and the falling of the fruit from the tree (D). The fruits of *S. alba* dropped off the mother tree and start to decay (Teo 2013).

The development of the flower is started from the emergence of flower buds, followed by the formation of buds which petals are about to bloom where it takes place within 33 days. Furthermore, from the buds where petals are ready to bloom up to the time the flowers completely which only, occurs overnight. The flowers bloom at night. The flower bloom and then wither the next day after successful pollination which is characterized by the falling stamens.

The pollination flower of *S. alba* occurs with the assistance of bees when the flowers are in a state of perfect bloom at night until morning. The occurrence of pollination is marked by the falling stamens of the flowers. According to Tomlinson (1994), each flower of Sonneratia generally only functions within one night.

After the flowers wither, then the ovaries are shown and formed during the 7 days. Then, after the ovaries are formed, they develop into the young fruit which is characterized by magnification of the ovaries and the drying of the flower buds. It takes 38 days for the young fruit to become ripe fruit, with dark green skin color and the surface of the fruit is smooth. The fruit is classified as ripe fruit if it is characterized by the falling of the fruit from the tree, but it left the petals which still remains on the tree's twigs. The stages of the phenology and number of days of each stages as shown in Table 2.

The emergency of flower buds began with a small bud at the tip of the twig which was found in middle of July. *S. alba* experienced flowering throughout the year. The small buds developed into buds and there were one to 3 flowers per group in each end of the twigs. The time of the development of the shoots until they became the buds which were ready to bloom took longer time than the other stages, starting from the middle of July until late of August.

The complete bloom of the flowers occurred in early September until the flowers wilt in the middle of September. The ovary is formed beginning from the middle of September until the end of September. The young fruit was formed and developed beginning from the end of September until it became ripe fruit in early November. This indicates that the development of the flowers into fruits of *S. alba* in the BSNP lasted for approximately 101 days. The phenology of *S. alba* is a distict possibility in a different place to grow (Lugo and Medina 2014).

The stage of *S. alba* flower development to become ripe fruit was started with the emergency of flower buds, the flower buds are ready to bloom, the flowers bloom, the ovaries are formed into the young fruit and ripe fruit. The stage of development of the buds into becoming flowers and the development of the young fruit into ripe fruit took a quite long time. A further study on the mangrove in the arboretum area of BSNP needs to be carried out. Sonneratia has the potential for restoration projects of degraded mangrove areas (Setyawan 2009; Munandar et al. 2014). Seasonal pattern of tree growth, one often related to rainfall, temperature and relative moisture (Krauss et al. 2014). The characteristics of mangrove fruit maturity will help to regenerate mangrove (Upadhyay and Mishra 2010). The phenology stage of *S. alba* in BSNP that was started with the initiation of the flower until the fruit is ripe, occurs within 101 dyas. The information on the reproductive phenology of *S. alba* can be used as the basline data in managing the mangrove area. The phenology of mangrove plays an important role in the rehabilitation program of the degraded mangrove area.

Table 2. The stages of the phenology and the duration of the development of reproduction of *Sonneratia alba*

Stages of phenology	Duration	Number of days
Initiation of flowering	19 Jul-26 Jul	7 days
Small buds	26 Jul-4 Sep	40 days
Large buds	4 Sep-10 Sep	6 days
Blooming flower	10 Sep-12 Sep	2 days
Young fruit	12 Sep-20 Oct	38 days
Ripe fruit	20 Oct-28 Oct	8 days
	Total	101 days

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