

Phenology of Flowering, Pollination and Fruit Set in the *Dendrobium Lineale* Rolfe

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Abstract: *The study aim was to understand development of flowers, pollination mechanism and fruit development of *Dendrobium lineale* which expected to provide scientific knowledge and useful information for cultivation and plant conservation efforts. The study had used descriptive observational method. The data was obtained from flowering, pollination and fruit forming had analyzed descriptively. Besides, the observation toward environmental factors of flowering phenology, pollination and fruit formation on *D. lineale* included minimum and maximum temperature, moisture and light intensity. The result found the duration in the flowering process of *D. lineale* Rolfe (between bud phase and perfect blooming phase lasting before wilting) was 4 months. The longest time required in the *D. lineale* Rolfe fruit formation (between fertilization phase and fruit growth and development phase) was 3 months. The flowering stages which occurred in *D. lineale* Rolfe consisted bud phase, flower bud phase, resupination phase, broken bud phase and bloom phase. The successful artificial pollination techniques on *D. lineale* Rolfe with “selfing” is shown by the formation of the fruit on the plant itself. The morphological changes which occurred during the flowering phase until the fruit formation indicated changes in shape, size and colour of the flowering buds, flower and fruit.*

I. INTRODUCTION

Indonesia is covered an area of 7.7 million km² which consisted 1.9 million km² of land and rest is the ocean. There are 17 000 islands and covered 47 natural ecosystem which estimated 28,000 plant species [1]. Every life and ecosystem have different abilities to meet their needs. The differences in fulfilling the need which form plant communities have certain characteristics included trees, shrubs, climbers, strangulation, parasites and epiphytes [2].

In Indonesia, plant which are epiphytes is reached 10% of vascular plant that divided into 850 genera and 65 tribes [3]. Highest number is Orchidaceae (orchid) tribe which covered 25,000 species. Orchid is ornamental plant type which had high economic value and is very prospective to be cultivated as income source and employment opportunities. High demand for orchids shows that large potential market for the orchid.

High demand of orchid is *Dendrobium* due to easy maintenance, flower can last up to 150 days and 20 flowers per flower stalk. Besides, *Dendrobium* orchid had variety of flowers, shapes and sizes. *Dendrobium* are widely found in Indonesia forest and have potential become crossbred parent in crop cultivation but not been widely used.

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In additions, obstacles in orchid development included limitation of superior seed due to lack of biology information on orchid types, simple technology usage and undistributed of existing technology. *Dendrobium* are widely used as crossbred mothers are from *Phalaenantha* and *Ceratobium* sections. *Ceratobium* section has star shape which also decrease the trait to its offspring. One of *Dendrobium* genus with *Ceratobium* section is *Dendrobium lineale*. *D. lineale* is belonged to *Ceratobium* section and grouped in *Ceratobium* (spatulate) section since the petals are twisted and shaped like antelope horns.

The knowledge about flowering phases especially flowers and fruit development of a plant or termed phenology is very important for the knowledge expansion and benefit of scientific development [4]. Study on flowering phenology and fruit formation on *D. antennatum* had been carried out by Ingastrin [5] found flowering duration was 29-30 days and fruit formation period were 107-111 days after the pollination. Selop orchid flowers (*Paphiopedilum glaucophyllum*) which have flowering period throughout the year [6].

Phenological studies had covered duration from flower appearance to fruit ripening, pollination, morphological changes occur which useful in orchid cultivation and plant conservation. The study aim was to understand development of flowers, pollination mechanism and fruit development of *D. lineale* which expected to provide scientific knowledge and useful information for cultivation and plant conservation efforts.

II. METHODOLOGY

The study was conducted at DD'Orchids Nursery in East Java and Plant Physiology Laboratory, Airlangga University within 7 months between October 2014 and April 2015. The study had used descriptive observational method. The data was obtained from flowering, pollination and fruit forming had analysed descriptively. In additions. the observation toward environmental factors of flowering phenology, pollination and fruit formation on *D. lineale* included minimum and maximum temperature, moisture and light intensity. There were 3 stages included flowering, pollination and fruit set stages.

The main flower stalk was measured at the growing point base to the tip of the flower as in Figure 1. The measurement was made since the prospective of main flower stalk emerges by using a thread and sliced with precision of 0.05 mm. The bud length is measured at the base of the growing point on the flower stalk to the end of flower bud as in Figure 2.

Phenology of Flowering, Pollination and Fruit Set in the *Dendrobium Lineale* Rolfe

The measurement were made using yarn with accuracy of 0.05 mm. Meanwhile, stalk length measurement were measured at the growing point base on the main flower to the flower stalk end. The petal length is measured when the flower bud entered the bloom phase. The sepal tear length is measured when the flower bud entered the broken bud phase. Flowering time is first flower buds until flower is withered. The listing of flower buds that appeared to be marked with label paper.

The observed morphological characteristics included flower shape, sepal shape, petal shape, sepal tip shape, petal tip shape, labellum shape and curve. The observed structures included polynya length and width. The pollination time was done when the flowers had bloom perfectly (anthesis). The pollination time was done by using the label paper contained date, month and year of pollination. The pollinia viability (by random pollination) was done by making the flower pollination had bloom perfectly on each main flower stalk. The random flower was selected which located at the base, middle and tip of flower buds. The fruit formation time was fertilization process time in the fruit formation phase until the mature fruit. The presence or absence of the sheath is observed since prospective of main flower bud appeared until the bloom phase. The direction of flower bud rotation occurred when the flower bud entered the resupination phase (rotation). The angle formed by the flower bud is measured using bow with flower stalk as its centre. The colour appearing was observed on interest sections and recorded on the morphological characters table.

The labellum colour was colour that dominated the whole labellum since purple in *Dendrobium antennatum*, black on *Coelegyne Pandurata* and yellow on *Phalaenopsis amabilis*. Meanwhile, labellum pattern is observed by the presence of

special patterns in the labellum such as patches, spots, lines, specks and other specific patterns. The light intensity was done by using lux meter. The observation was made since bud phase until the fruit formation phase. The moisture measurement was done by using Sling psychrometer. The minimum and maximum temperature was measured using Sling psychrometer.

III. RESULT AND DISCUSSION

Flowering stage consisted five phases included bud, flower bud, resupination, broken flower bud phase and bloom phases.

In 1st week observation, there were no significant changes in colour in the flower buds and flower bud pedicel. In resupination process, the angle formation by the flower bud on the flower stalk changed from 00, 900 and 1800 until horn-like formation position (bt) on the flower bud which was originally at top changed to below.

Any flower bud through resupination phase had experienced broken flower bus phase. All flower parts were sepals, while, petal and labellum from *Dendrobium lineale* did not appeared since wrapped by the sepals. The sepal dorsal and lateral had distinguished with straight line pattern on the flower bud. The initial condition of the flower bud after resupination was in sword tip shape with sepal dorsal length was 2 cm.

In bud rupture phase, the sepal dorsal side and lateral were tangent to each other which flower bud was rupture until the gynostemium of flower was seen. The tear of sepal grew to 1.82 cm, the petal formation became visible and the flower bud became more budging during the observation at 11 am.



Fig. 1 The rupture flower bud phase. (A) rupture flower bud 1.82 cm front view, bar= 0.22 cm (C) rupture flower buds 1.82 cm side view, bar=0.22 cm, sd= dorsal sepal, sl=lateral sepal, ps= sepaltear length

Meanwhile, dorsal sepal tear length became 1.91 cm at 14 pm, small cavity is formed between the petal and dorsal sepal with good scent. The petal had purple colour and flower stalk length remained at 5.57 cm. In 3rd day, the dorsal sepal length became 2.12 cm and sepal tear length turned to 2cm. Two small cavities are formed between the petal with the dorsal and lateral sepals. The two cavities in the flower bud resulted in stronger scent, but there is no visible formation of the labellum. The curved looking petal was pushed the dorsal and lateral sepal, consequently the

petal formation is appeared. The push from the petal caused the sepal tear to expand. The petal curve is clearly visible but the flower buds was not rupture due to end of the dorsal and lateral sepals are still attached to each other.

The tear on sepal length was 2.11 cm and dorsal sepal length was remained unchanged.

The flower stalk length was 6.09 cm. The dorsal sepals are perfectly open and appeared to curve upward. The petal and labellum formation were clearly visible with strong scent.

The blooming phase consisted the bloom phase I and II. The bloom phase I occurred after the bud phase ruptured. The first stage in first bloom phase was opening of the lateral sepals in both sides. The lateral sepal length was 2.13 cm, dorsal sepals was 2.15 cm, petal length was 2.16cm and flower stalk length was 6.09 cm. The petal was not open but the labellum shape was observed. The gymnostemium was invisible since its covered by the hypochillium part of labellum. The petal and epichillium from the labellum still intersected. The mother flowering stalk had reached at 62.35cm.

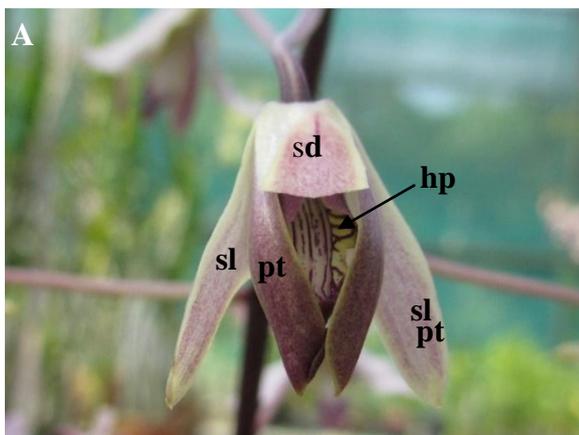


Fig. 2 The blooming phase I. (A) First stage bloom phase, bar=0.67 cm, sd=dorsal sepal, sl=lateral sepal, pt=petal, cell=hypochillium

In 2nd stage, the gymnostemium began to observe dinvrhipochillium part of the labellum was exposed. The hypochillium and petal sections are still intersected but the petal and epichillium part had been separated. The lateral sepal tip also was opened. The dorsal sepal length was 2.16cm, lateral sepal length was 2.15 cm, petal length was 2.17cm and flower stalk length was 6.09cm. The flower stalk was in purple colour, while lateral sepal and sepal dorsal were dominated by white colour with purple shade but petal was in purple colour. IN 3rd stage, hypochillium and petal was no longer intersect. The petal section is more widen until stress on lateral sepal. The mesochillium part of labellum began to appear, hypochillium began to open while the base was not open. The sepal dorsal and lateral sepal lengths were remained unchanged. 1st phase in the blooming phase is marked by the lifted of petal which petal had no longer be tangent with sepal dorsal, sepal lateral and labellum. The sepal lateral began to be curve on the side. The dorsal sepal had reached 2.30cm, lateral sepal length was 2.25, petal length of 3.00cm and flower stalk length of 6.38cm.

The 2nd stage is marked by the rising of petal upward and started to bend backwards. The lateral sepal curve on the side increase, the dorsal petal began to experience curvature on the side. The dorsal sepal length was 2.30cm, lateral sepal length was 2.31cm, petal length was 3.03cm and flower stalk length was 6.38cm. In 3rd stage, end of dorsal

sepal and lateral sepal was curl backward. The epichillium, hypochillium and mesochillium from labellum had fully bloomed. The dorsal sepal length was 2.33 cm, lateral sepal length was 2.35cm, petal length of 3.14cm and flower stalk length was 6.40cm.

The flower bud was bloomed in not simultaneous which first blooming was flower had lied in the mother flowering stalk base area. *Dendrobium lineale* Rolfe are not polished had last up to 8 weeks until 9 weeks which the flower will wither, dry and die. In additions, the column (gymnostemium) of flowers that were not polarized appeared to dry out and wrinkles. The dorsal and lateral sepal forms were oblong with the curved side, while the petal shape was oval. The dorsal sepal and lateral sepal were blunt and formed petal tip.

IV. DISCUSSION

In this study, flowering *D. lineale* was racemose type which is compound flower with mother flowering stems that can grow continuously and produced large number of flowers. *D. lineale* was belonged to epiphytic orchids which had sympodial stem growth, node and segment steams, pseudobulb appeared on the stem with cylindrical shape.

The dorsal sepal had maximum length of 2.42 cm and white colour combined with purple patch. The sepal curved back, and dorsal segment edge was curve. The lateral sepal had maximum length of 2.45cm, white colour with purple patch, sepal curved to the side and there are curves on the sepal edge. The two petals shape look likes antelope horn with upright growth upward and petal was twisted. The petal colour was purple with maximum length of 3.1cm.

D. lineale and *D. antennatum* was orchids which belonging to *Ceratobium* section (*Spatulata*). The advantages of *D. antennatum* are 2 times petal was twisted which *D. lineale* only had one twisted petal. Labellum is petal modification had various unique shapes. Labellum on *D. lineale* was shaped like tongue with length of 2.72cm with dominated colour by purple, yellow and white. The hypochillium part of labellum was dominated by yellow accompanied by horizontal lines pattern that spread to the right and left. The mesochillium is dominated by white and purple vertical line pattern. Meanwhile, epichillium portion of the labellum was dominated by purple and no pattern. Grub et al. had found labellum in *paphiopedilum rungsuriyanum* shaped likw helmet with lateral side folded in, the neckline is shaped like letter V (visible from front), labellum length was 2-3 cm and width of 1.2 cm with brownish colour, back was yellowish colour and labellum colour was green [7]. Meier et al. [8] stated labellum had important role in pollination ecology which labellum had a colour that attracted the pollinator.

Phenological observation of flowering in *D. lineale* showed there was a change in shape and size of the mother flowering stalk, flower stalk and flower bud. In the budding phase, the mother flowering stalk continued to experience increment until stagnant state. The stems and flower bud lengths were 5.51cm and 3.11 cm during flower bud phase until bloom phase.

Phenology of Flowering, Pollination and Fruit Set in the *Dendrobium Lineale* Rolfe

The flower buds also experienced resupination which had begun to differentiate the dorsal and lateral sepals. In rupture bud phase, dorsal and lateral sepal was divided and began to appear on blooming phase.

The resupination phase was interesting process which labellum was in right position during rupture bud phase. The labellum always undergone modification and resizing [9]. The labellum had experienced the rotation process of medial petal (labellum) and other parts. The labellum had experienced the rotation so that original position moved from top to bottom position. During the flowering process, the scent changes also occurred and appeared in the breakout phase until the bloom phase. The scent was invited pollinators to the flowers itself [10].

The pollinia base and tip had moderate depth of indentation. The pollen was based on the location and shape of the wrinkles groups in the tetrad type (had 4 wrinkles) which had tetrad decussate type and based on the pollen size included medium type. The toothpick was used in pollination since easily to be adjusted regarded to the flower size for pollination. The artificial pollination by hand-pollination (selfing) was done by pick the sticky fluid found on the stigma with toothpick and slowly open anther cap so that pollinia would be pushed and attached to the toothpick.

The morphology observation is in full bloom (anthesis) as well as identification of pollinia viability is very important in helping the pollination of orchids. The flowers had undergone anthesis indicated that the flower is ready to reproduce with mature breed. Most pollen viability test are pollen germination techniques in vitro.

During the fertilization phase, flower stalk and gynomestemium experienced swollen. The swollen in *D. lineale* was different from swollen in the *Paphiopedilum glaucophyllum* orchids which occurred at the middle part [11].

In the fruit initiation phase, potential fruit had been formed. The prospective fruit had developed into fruit with largest diameter at middle part and colour was changed indicated fruit was mature. The fruit formation successful also influenced by flowering positions. The fruit are often formed on flowers which in bottom flowering position [12].

Fruit formation is an important process in the plant reproduction. The fruit developed from the ovary which undergone fertilization. The fruit formation in orchid is always related to the pollination system that occurred in the orchid. In *D. lineale*, fruit formation could occur through the artificial pollination by selfing.

Overall, the flowering process until the fruit formation required total length of 7 months. The flowering mechanism was taken 4 months which included shoot phase, flower bud, resupination, rupture bud and blooming phased. The fruit formation was lasted for 3 months which included fertilization, fruit initiation, fruit growth and development phases. The artificial pollination mechanism in *D. lineale* took place during the fertilization phase of fruit formation.

Environmental parameters are influenced on growth and development. During the flowering, pollination and fruit formation were influenced by environmental factors. The blooming, pollination and fruit formation of *D. lineale* also had range of wet and dry temperatures, humidity and certain light intensity. Overall, pollination and formation of *D.*

lineale occurred at an average dry and wet temperatures of 28.380C and 23.94 0C, humidity of 70.44% and light intensity of 2464.06 λ .

V. CONCLUSION

In conclusions, the duration in the flowering process of *Dendrobium lineale* Rolfe (between bud phase and perfect blooming phase lasting before wilting) was 4 months. The longest time required in the *Dendrobium lineale* Rolfe fruit formation (between fertilization phase and fruit growth and development phase) was 3 months. The flowering stages which occurred in *Dendrobium lineale* Rolfe consisted bud phase, flower bud phase, resupination phase, broken bud phase and bloom phase. The successful artificial pollination techniques on *Dendrobium lineale* Rolfe with “selfing” is shown by the formation of the fruit on the plant itself. The morphological changes which occurred during the flowering phase until the fruit formation indicated changes in shape, size and colour of the flowering buds, flower and fruit.

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