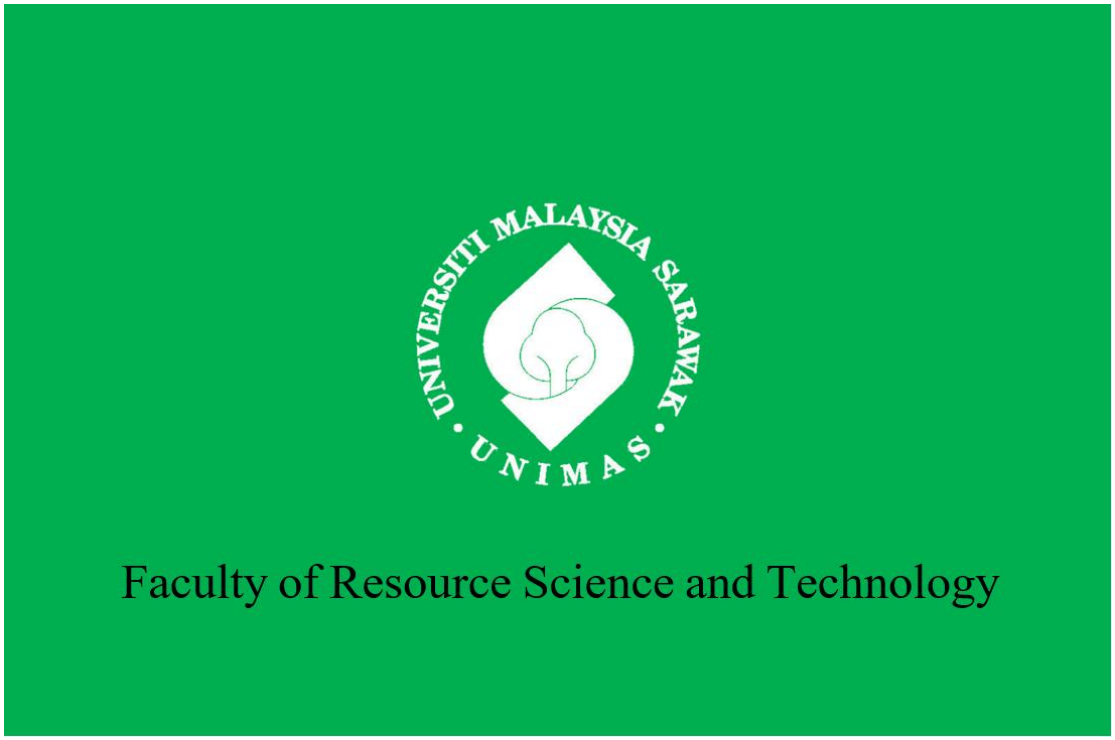

Flowering phenophases of *Arundina graminifolia* and *Arundina graminifolia* subsp. *caespitosa* based on the BBCH-Scale

Nurul Fatin Binti Zolpata (72836)

Bachelor of Science with Honours
(Plant Resource Science and Management)
2022

Flowering phenophases of *Arundina graminifolia* and *Arundina graminifolia* subsp. *caespitosa* based on BBCH-Scale

Nurul Fatin Binti Zolpata

A thesis submitted in partial fulfilment of the Requirement of The Degree Bachelor of Science with Honours

(Plant Resource Science and Management)

SUPERVISOR: DR MOHD AKMAL BIN MOHD RAFFI

Programme of Plant Resource Science and Management

Faculty of Resource Science and Technology

UNIVERSITI MALAYSIA SARAWAK

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Flowering phenophases of *Arundina graminifolia* and *Arundina graminifolia* subsp. *caespitosa* based on BBCH-Scale

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ABSTRACT

Arundina graminifolia is a monospecies and a terrestrial plant that is commonly known as bamboo orchid. *Arundina graminifolia* can be further classified into two subspecies and one of them are *Arundina graminifolia* subsp. *caespitosa.* There are a number of significant distinctions between *Arundina graminifolia* and *Arundina graminifolia* subsp. *caespitosa* and this discrimination may serve as an indicator it can be further distinguished. Therefore, the findings of this study may have contributed to a change in their viewpoints on the taxonomic classification and as a a references in the future to enhance the knowledge on the species and subspecies. The main objective of this study were to define the flowering phenophases stages of the of *Arundina* and its subspecies based on the BBCH scale as well as to compare the phenological phases of *Arundina* and its subspecies. The study discovered that there are distinct behaviours that have been discovered, including the duration of the flowering lasted, the inflorescence and bud phases and the flowering stages of *Arundina graminifolia* and *Arundina graminifolia* subsp. *caespitosa.*

Key words : *Arundina graminifolia, Arundina graminifolia* subp. *caepitosa,* BBCH-scale, flowering phenophases.

ABSTRAK

Arundina graminifolia merupakan sejenis monospesies dan tumbuhan darat yang biasa dikenali sebagai orkid buluh. Arundina graminifolia boleh dikategorikan kepada dua subspesies dan satu daripadanya ialah Arundina graminifolia subsp. caespitosa. Terdapat beberapa perbezaan ketara antara Arundina graminifolia dan Arundina graminifolia subsp. caespitosa dan diskriminasi ini mungkin berfungsi sebagai penunjuk ia boleh dibezakan lagi. Oleh itu, dapatan kajian ini mungkin telah menyumbang kepada perubahan dalam pandangan mereka terhadap klasifikasi taksonomi dan sebagai rujukan pada masa hadapan untuk meningkatkan pengetahuan tentang spesies dan subspesies ini. Objektif utama kajian ini adalah untuk mentakrifkan peringkat fenofasa berbunga Arundina dan subspesiesnya berdasarkan skala BBCH serta membandingkan fasa fenologi Arundina dan subspesiesnya. Kajian mendapati bahawa terdapat tingkah laku berbeza yang telah ditemui, termasuk tempoh berbunga berlangsung, fasa perbungaan dan tunas dan peringkat berbunga Arundina graminifolia dan Arundina graminifolia subsp. caespitosa.

Kata kunci : *Arundina graminifolia, Arundina graminifolia subp. caepitosa, skala BBCH, fenofasa berbunga.*

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LIST OF ABBREVIATION

BBCH	Biologische Bundesanstalt, Bundessortenamt and Chemical Industry

CHAPTER 1

INTRODUCTION

1.1 Background

Orchidaceae is one of the world's largest flowering plant family with over than 25,000 species that are divided into approximately 1,000 genera. *Arundina graminifolia* is one of many monospecific plants in this family. It is a terrestrial plant often known as bamboo orchid, valued for its beauty and adaptability to many environments. In the wild, this species can be found in many habitats throughout the subtropical and tropical. The wide range of habitats that offers different types of environment have resulted in the phenotypic variations in *Arundina graminifolia* where it was classified into two subspecies namely *Arundina graminifolia* subsp. *graminifolia* and *Arundina graminifolia* subsp. c*aespitosa* (POWO, 2021)

In general, *Arundina graminfolia* and *Arundina graminifolia* subsp. *caespitosa* (the subjects of this study) have some similarity in terms of their morphology but are distinguished by their habitats, as well as their overall shape and sizes (Pedersen & Schuiteman, 2014). The discrimination may serve as an indication that they can be further distinguished and that might provide a new perspective on their taxonomic classification.

Thus, an additional botanical method needs to be investigated for the evaluation in order to prove or support this statement. One of the potential approach is *via* phenological study. Phenology is used to determine a species' developmental stage, which can help distinguish between species and subspecies morphological complexities as phenological events could be used to assist the discriminate of species (Schwartz 2003; Sobhan, 2007; Blackford et al, 2020).

Additionally, changes in flowering stages can be used to separate *Arundina graminifolia* and *Arundina caespitosa*, as flowers enabled to develop a more species-specific structure, allowing them to evolve more rapidly into distinct species without the risk with related species. Hence, the purpose of this study is to define the flowering phenophases stages of the of *Arundina* and its subspecies based on the BBCH scale as well as to compare the phenological phases of *Arundina* and its subspecies.

CHAPTER 2

LITERATURE REVIEW

2.1 Classification of *Arundina graminifolia*

2.1.1 The genus of *Arundina*

According to Rakosy et al (2013), *Arundina* is a genus name that comes from *arundo* that derives from the Greek word which actually refers the plant's like reed stems, while the term of *graminifolius* that comes from the Latin words which is *gramineus* and *folius* that refers to the grass leaves like. This species has a weed-like habit when the orchid's flowering phase arrives, it is easily identified by its attractive colour among a population of tall grass (Kurniawan & Semiarti, 2021). *Arundina graminifolia* are native to tropical and subtropical Asia from the Himalayas to South-East Asia that includes Malaysia, Indonesia, Singapore, New Guinea and Philippines (Chowdhery, 2001; Pridgeon et al, 2005). This bamboo orchids can grow naturally in various places such as alongside roads and are appreciated for their beautiful flowers that has high ornamental and medical value. *Arundina* blooms all year in Malaysia, Indonesia, and Philippines (Epharmacognos, 2020). However, in other areas, the flowering time varies. As for example, August-June in Tripura; April-September in Sikkim; June-November in Myanmar and August-March in Thailand (Debnath et al,2016; Panda & Mandal,2013; Arseniuk,2021). Li et al (2012) added, *Arundina gramnifolia* was traditionally used as an antidote and demulcent in herbal medicine and this plant is said to have anti-arthritic and anti-irritating properties. Xiaohua et al, (2015) added, the entire plant is mostly use in Dai medicine to cure blood stasis, food poisoning, and as a liver detoxifier. In addition to that, the stems of *Arundina*

graminifolia are considered useful for herbal teas when completely matured and firm before the leaves turn yellow (Lan Zhao, 2013). Due to the its diversity of environmental conditions, *Arundina graminifolia* has been categorised into two subspecies and one of them are *Arundina graminifolia* subsp. *caespitosa* (Averyanov et al, 2018)

Figure 1 *Arundina graminifolia*

Figure 2 *Arundina graminifolia* subsp. *caespitosa*

2.1.2 Morphological differences of *Arundina graminifolia* and *Arundina graminifolia* subsp. *caepitosa*

A subspecies can be stated as a group of populations that share a similar reproductive area but are diagnostically different from one another (Patten, 2009). According to Hey (2009), it is believed that what distinguishes species from subspecies and genera is the ability of creatures within a species to reproduce for example the generate fertile offspring with one another, but not with organisms from other species. The early definitions of subspecies defined groups of individuals that share pattern, colour, or morphological characteristics not shared by other, geographically dispersed populations of the same species (NAP, 2019). Scheepens et al. (2011) further stated that while morphological differences enable the species and its subspecies to be identified in the field, no study has been conducted on the process of phenological stage differences in various characteristics. Sultan (2000) added, botanists have occasionally discovered that presumed subspecies characteristics are just the result of environmental differences, hence it is critical to consider environmental factors when taxonomic classification is concerned. Prothero (2007) mentioned, eventhough the modern species ideas differ in certain ways, they are always aimed at recognising groups of creatures whose reproductive compatibility ensures genetic continuity.

According to Tschopp et al (2021) significant evidence of a species based on morphology is based on the specimens exhibit phenotypes unique from those of other designated species while the subspecies is based on the evidence within the species that it belongs to of a geographically and historically isolated lineage. Although ecological isolation is considered as significant in speciation, it depend on how species are defined and differences in taxonomic practises can affect patterns of species diversity, which it makes the comparisons across taxa is difficult (Isaac et al.

2004; Smith et al. 2013). Andrei (2021) added, individuals within a subspecies may differ in morphological character states from other individuals, but do not constitute distinct subspecies, showing instead that the population is polymorphic.

Hence, the resemblance of *Arundina graminifolia* and *Arundina graminifolia* subsp. c*aespitosa* is difficult to identify however, there are proved that there are differences in morphological that distinguish between slender, narrow-leaved, small flowering plants from stout, broad-leaved, large flowering plants (Pedersen & Schuiteman, 2014). Averyanov (2007) added, *Arundina caepitosa* is significantly different from the widely distributed, common and extremely varied species of *Arundina graminifolia* in that it has smaller size throughout, habit, linear shiny dark green leaves, small bright purple flowers, and a different ecology. Differences in phenology may be hypothesised on the basis of the varied settings in which the subspecies live (Scheepens et al, 2011). To simplify identification of the species and its subspecies, the following morphological characteristics of the species are listed in below (Averyanov, 2007; Puccio, 2009; Debnath et al, 2016)

Table 1 Morphological characteristics of *Arundina graminifolia* and *Arundina graminifolia* subsp *caespitosa*.

Structure	*Arundina graminifolia*	*Arundina graminifolia* subsp. *caespitosa*
Leaves colour	Dark green and yellowish green leaves colour	Dark glossy green with articulated at the base with light greenish colour to yellowish
Leaves size	7-20 cm long	10 to 18 cm long
Flower	Yellowish green, pinkish, white, purple flower colour	Vibrant purple flowers colour

Flower size	7cm in diameter.	3-4cm in diameter.
Floral bracts	Broadly ovatetriangular, 3–5 mm	Broadly ovate, 2-4 mm long.
Petals	Ovate-elliptic about 3.5cm long	Oblong-elliptic with 1.8-2.4 cm long, 6-8 mm in width
The lip/labellium	Sessile with a trumpet shaped.	Sessile and has a shaped of trumpet.
The column	White in colour and approximately 20-25mm length	White in colour around 10-12 mm length, 0.8-1.2 mm width
Fruit shape	Cylindrical capsule ridged fruit	Cylindrical ridged capsule fruits
Fruit sizes	3-3.5 cm long	1.4-2.8 cm long
Operculumn	White operculum approximately 3mm	White operculum approximately 1-1.2 mm
Habitats	Open areas, grassland, mountains and rock places by streams	Open wet sandstone and granite stream and rivers rocks along water line

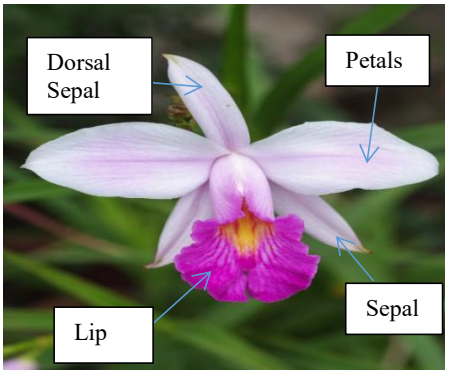

Figure 3 Floral Part of *Arundina graminifolia*

2.2 Phenology as alternative classification

Phenology is the study of the events that occur during the living organism life cycles (Liang,2019). Keller (2020) added that phenology aims to characterise the factors that influence the timing of the events with the dates of certain growth events and the gaps between them. Number of studies have proved that the life-cycle characteristics of terrestrial ecosystems are highly dependent on ambient temperatures (Gordo & Sanz, 2006). Phenology is largely used as a measure for observing the effect of climate factor on ecosystems and the organisms that comprise them (Eionet, 2021) Plants are the most common subject of phenological research because they are stable and can be looked at over and over again (Zhao et al, 2013). Budbreak, leafing, flowering, fruiting, and leaf colour are all frequent growth stages that are subjected to phenology can be referred as phenophases (Kubin et al, 2007).

Phenology studies the relationship between the phenophases of plants that belong to the same or different species and their timing in response to different types of stimuli (Garnier, 2009). Although flowering phenology is genetically differentiated between the species however, climatic factors influence the timing of flowering within subspecies where numerous scientists that studies phenology believe that the timing of life phases is directly related to seasonal climate and also has an effect on an individual's abilities to survive, reproduce, and compete (Scheepens et al, 2010; Chhetri et al, 2020). Phenological characters can contribute to categorization in the same way that any other possible character can, and so their utility will be determined only once the distribution and variation of taxa are known (Fores et al, 2018). Consequently, certain phenological traits can be used to distinguish between the two species, although most of the characters are of the quantitative variety and so because

of changes in the distribution of inflorescences and the timing of induction, it is likely that these differences vary from region to region (Chuine, 2010; Fores et al, 2018). The phenological pattern displayed by an individual as an example, the date of germination; the beginning and duration of flowering; the average number of flowers open each day during the flowering season; and the period of seed dispersal is typically a result of both genetic and environmental effects (Haggerty & Mazer, 2008). The requirement for a common terminology also applies to the description of plants' phenological growth stages where BBCH provides an excellent foundation for satisfying the scientific demand (Meier et al., 2009).

2.2.1 BBCH scale as phenological identification

BBCH scale refers to Biologische Bundesanstalt, Bundessortenamt and Chemical Industry to identify the phenological stages of plant growth. According to Meier et al, (2009), the BBCH-scale is a phenologically identical development growth stages of classification system for all monocotyledonous and dicotyledonous plant species. Another explanation of the BBCH-scale is that it is used to characterise the phenological events of agriculturally important plants and to meet the demand for a fundamental understanding of biology and critical stages of a plant's life cycle. (Chastain, 2015). Additionally, the BBCH scale provides a more precise description of the plant's morphological and anatomical characteristics (Niemenak et al, 2010). The BBCH scale uses a decimal code in which the same code is assigned to similar growth stages in several plant species as it is a precise and straightforward method for identifying plant phenological growth stages based on readily observable external morphological characteristics (Piga et al, 2018). The primary growth phases refers to time periods of a plant's development (Meier, 2001). Secondary phases are employed

when precise time intervals or stages in the plant's development must be stated. It is defined as small developmental steps specific to each plant species that occur sequentially during the principal growth stage in contrast to the primary growth stages. The stages are then categorised using the codes of 0 to 9. The two-digit code is created by combining the figures for the primary and secondary stages (Meier, 2001). According to Meier et al, (2009), the stages of growth typically begin with seed germination and continual sprouting, progress through leaf formation and extension growth, and conclude with flowering and senescence. The BBCH scale is strongly recommended for standardising work undertaken under a variety of climatic and experimental conditions (Leather, 2010)

Stage	Description
0	Germination / sprouting / bud development
1	Leaf development (main shoot)
2	Formation of side shoots / tillering
3	Stem elongation or rosette growth / shoot development (main shoot
4	Development of harvestable vegetative plant parts or vegetatively propagated organs / booting (main shoot)
5	Inflorescence emergence (main shoot) / heading
6	Flowering (main shoot)
7	Development of fruit
8	Ripening or maturity of fruit and seed
9	Senescence, beginning of dormancy

Table 2 The description of the stages (Meier et al, 2009)

CHAPTER 3

MATERIALS AND METHOD

3.1 *In situ* and *ex situ* observation of *Arundina*

In situ observations of *Arundina graminifolia* were conducted at PITAS, UNIMAS, whereas *ex situ* observations of *Arundina graminifolia* subsp. *caespitosa* were carried out in the PPT Orchidarium from March to April. A total of 30 flowers of *Arundina graminifolia* and 16 *Arundina graminifolia* subsp. *caespitosa* were assessed. The identification of *Arundina graminifolia* were describe by using Pederson and Schtuirman (2014) and *Arundina graminifolia* subsp. *caespitosa* were referred using Averyanov (2007). The temperature and humidity data were collected using Kestrel DROP 2 Smart Humidity Data Logger and AccuWeather (https://www.accuweather.com/) on a daily basis throughout the flowering event. The measurement of the flowers growth of *Arundina graminifolia* and *Arundina graminifolia* subsp. *caespitosa* were recorded by using ImageMeter. The duration of each flowering stages and the insect visitor on each species and subspecies were recorded. The description of the flower morphology at each flowering stage, which were from flower bud formation until senescence was photographed in the morning and afterwards described by using Beentje (2010). The modified BBCH scales that referred by using Meier (2009) were implemented to describe the principal growth stage 5 that refers to inflorescence and flower bud stages and principal growth stage 6 that refers to the flowering stages. The phases in each stages will be labeled as 0(start) to 9(end).

CHAPTER 4

RESULT

4.1 The flower phenology of *Arundina graminifolia*

In this study, 30 flowers from 16 individuals were assessed in which 15 of them were successfully evaluated. The remaining number of 15 flowers were unsuccessfully due to the damage done by multiple insects.

On the other hand, the result of the temperature and humidity of the species, *Arundina graminifolia* were recorded during the observation in Figure 4 and Figure 5. The highest temperature recorded was 35°C and the lowest temperature recorded were 29°C. The highest humidity noted was In this pattern, the 14th and 28th of April have the highest temperatures, while the 19th of April has the lowest temperature with 87% of humidity.

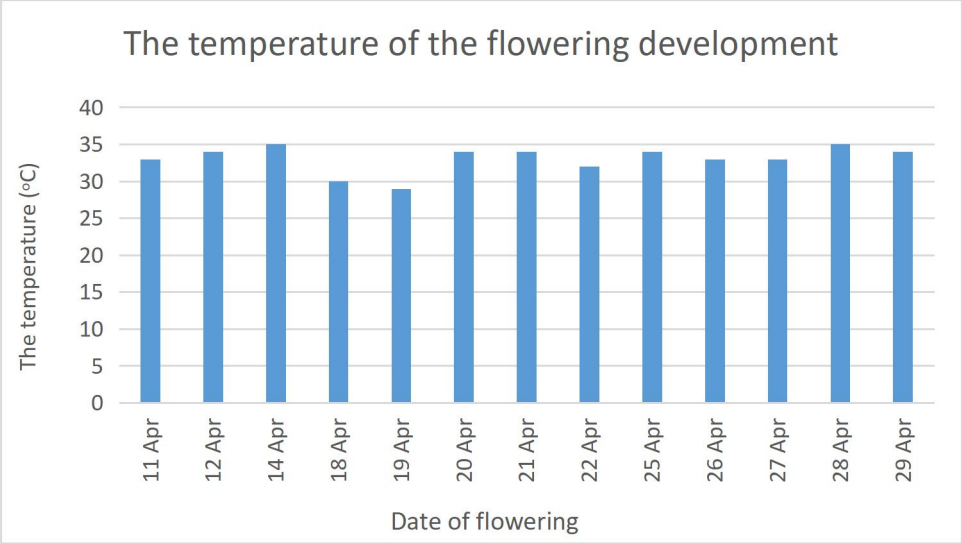

Figure 4 The temperature of the flowering development

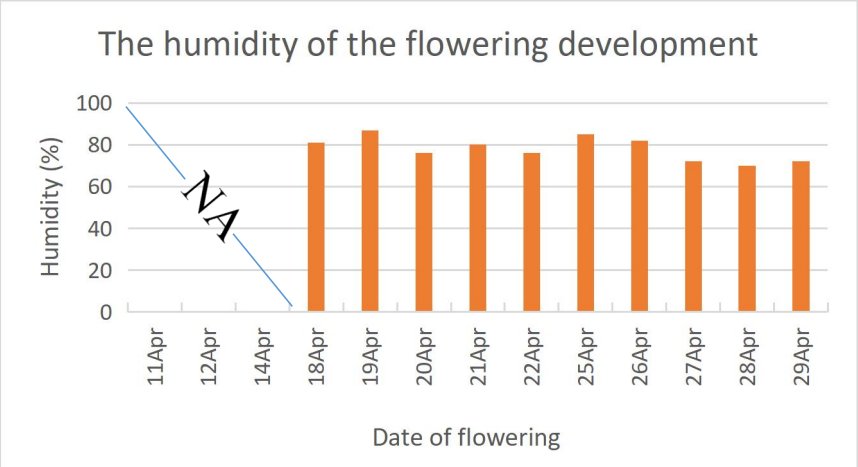

Figure 5 The humidity of the flowering development

4.1.1 The Inflorescence and bud stages of *Arundina graminifolia*

There were four stages that involved the inflorescence and flower bud growth as been depicted in Table 3 Figure 6. It started with fully developed flower bud (Stage 50) with a green colour with 10% increase of bud sized in length (Stage 51.). The bud then turn pink and the size increase 30% in length (Stage 53). It ended with the flower bud were ready to bloom (Stage 59).

Code	Descriptions
5	Inflorescence Emergence
50	Flower bud visible and inflorescence fully developed
51	Flower bud size increase 10% in length
53	Flower bud start to turn pink and size increase 30% in length
59	Flower bud ready to bloom

Table 3 Principal Growth Stage 5: Inflorescence Emergence

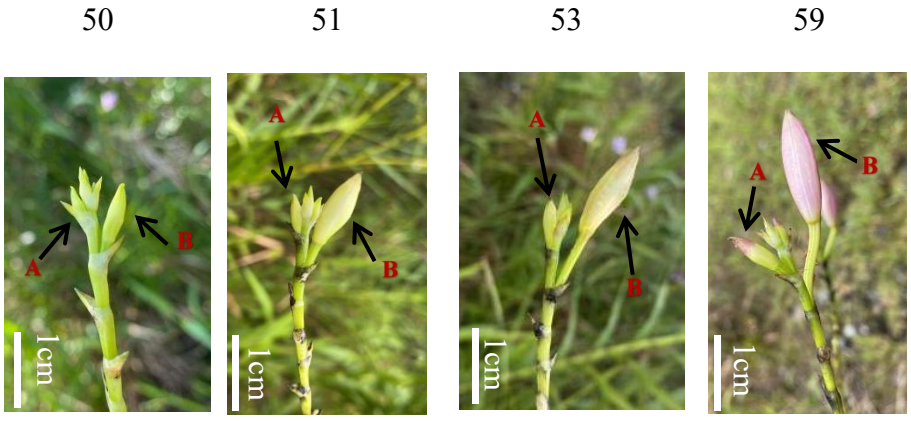

Figure 6 Lateral view of Inflorescence emergence of *Arundina graminifolia*