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NOTES ON EPISODIC GROWTH OF INFLORESCENCES IN *BARRINGTONIA FILIRACHIS* AND *B. RACEMOSA* (LECYTHIDACEAE)

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This study investigates the unique phenomenon of episodic growth in the inflorescences of *Barringtonia filirachis* and *B. racemosa* (Lecythidaceae), observed in herbarium specimens and living collections. Unlike conventional non-episodic growth, where the meristematic tip senesces after flowering and fruiting, episodic growth allows for successive cycles of flowering and fruiting within the same rachis. This growth pattern, characterised by alternating dormant and active zones along the rachis, was observed in both species, with distinct changes in rachis colouration reflecting growth phases. *Barringtonia filirachis*, an endangered species restricted to swampy lowlands in Peninsular Malaysia, and *B. racemosa*, a common and widely distributed species across tropical regions, both exhibit this reproductive strategy. These findings expand our understanding of reproductive dynamics in tropical trees and reinforce the conservation importance of conserving species like *B. filirachis* with such unique growth behaviours.

Keywords: Inflorescences, *Barringtonia*, Lecythidaceae, episodic growth

INTRODUCTION

Barringtonia J. R. Forst. & G. Forst. is the largest genus of the Old World Lecythidaceae, comprising 74 species (Payens 1967, Whitmore 1973, Kiew & Wong 1988, Chantaranothai 1995a; 1995b, Chuakul 2001, Pinard 2002, Takeuchi 2010, Prance 2010, Jebb & Prance 2011, Prance 2012a; 2012b, Rohana & Latiff 2012, Thammarong et al 2015; 2017) with a wide distribution across East Africa, Madagascar, South Asia, Malesia, New Caledonia, Australia, and the Pacific Islands. The habitats of *Barringtonia* include freshwater swamps, mangroves, streams, lakes, limestone areas, coastal littoral zones, and other inundated regions. Some species are also found in lowland forests, with a few extending into forests up to 1800 metres above sea level. Studies on the structure and species composition of tropical rainforests highlight the ecological importance of families such as Lecythidacae, including the genus *Barringtonia* (Lū et al. 2010).

This genus is easily recognised from the typical long pendulous inflorescences (when present). However, trees without inflorescences are often difficult to identify. Seven species have erect rather than pendulous inflorescences, *B. asiatica*, *B. corneri*, *B. khaouluangensis*, *B. lanceolata*, *B. pauciflora*, and *B. sarawakensis* (Payens 1967, Chantaranothai 1995b, Pinard 2002, Prance 2012a; 2012b). The inflorescences of *B. corneri* are more or less erect during flowering but become pendulous as fruits develop (Prance 2012a; 2012b). This change occurs because the developing fruits increase in weight, causing the inflorescence to bend; thus, they are not truly pendulous in the strictest sense.

The formation of inflorescences in *Barringtonia* is almost always terminal, axillary, cauliflorous, or ramiflorous (Payens 1967, Chantaranothai 1995a, Pinard 2002, Prance 2012a; 2012b). The rachis of the inflorescence is relatively short (less than seven cm) in species such as *B. jebbiana*, *B. lanceolata*, *B. maxwelliana*, *B. papuana*, and *B. pauciflora.* Conversely, some species, such as *B. sarcostachys* and *B. augusta*, produce rachises that reach impressive lengths exceeding two metres.

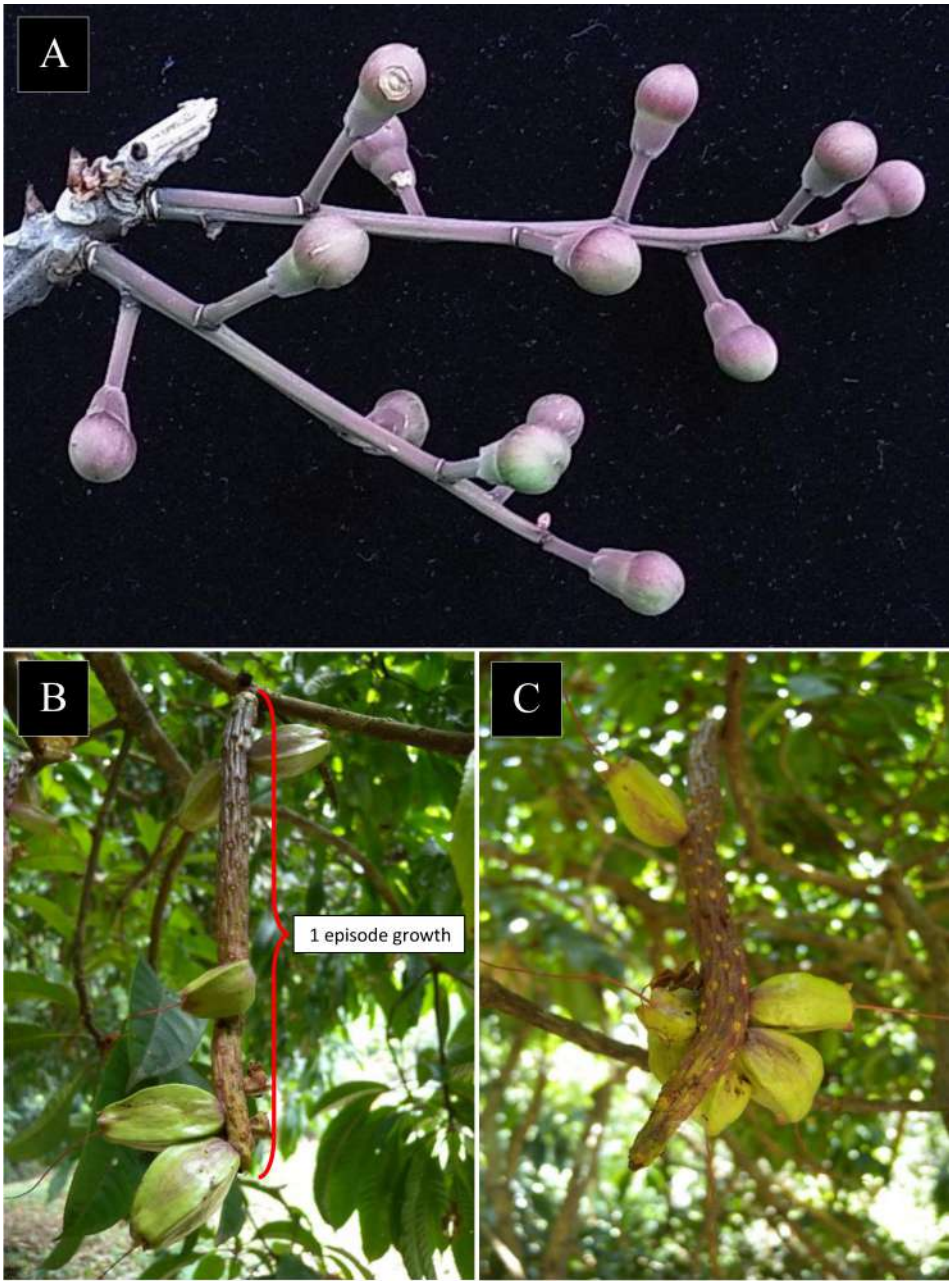

Figure 1A Inflorescences of *B. conoidea* (NSY 99) terminating with flower buds. This is an example of a single growth episode of inflorescence
Figure 1B Rachis of *Barringtonia macrostachya* (NSY 1051) ending with a fruit. An example of one-episode growth of inflorescence indicated in red
Figure 1C Dried tip of the rachis in *B. macrostachya* (NSY 1052) indicating the conclusion of a single growth episode

MATERIALS AND METHODS

Observations were conducted on both herbarium specimens and living collections housed at the Kepong Botanical Garden (KBG) within the Forest Research Institute Malaysia (FRIM), Kepong; Rimba Ilmu at the University of Malaya, Kuala Lumpur; Rimbun Dahan in Selangor; and the Singapore Botanic Gardens, Singapore. Specimens examined included *Barringtonia filirachis* (SFN 25890, NSY 101, 1020) and *B. racemosa* (SFN 31455, SFN 21194, NSY 1008, 899, 1003, 878, 999, 1004).

Field studies were conducted at Sungai Nipah Forest Reserve, Terengganu (04°16′34″N, 103°10′57″E), between 2009 and 2012. This site represents a newly recorded locality for *B. filirachis* in Peninsular Malaysia. Seven trees of

B. filirachis were observed in swampy lowland habitats, where episodic growth of inflorescences was recorded. Observations focused on rachis colouration, floral development, and fruiting patterns to identify active and dormant zones. Episodic growth was also confirmed on the type specimen of *B. filirachis* (SFN 25890), though it was not reported in the original taxonomic description by Payens (1967).

For *B. racemosa*, episodic growth was recorded in both botanical and private gardens. These included the Kepong Botanical Garden (NSY 1008, 899), Rimba Ilmu (NSY 878, 999), Rimbun Dahan (NSY 1003), and the Singapore Botanic Gardens (NSY 1004). Additional specimens were examined from the herbarium collection at SING (SFN 31455, SFN 21194). Despite successful flowering and fruiting, no seedling recruitment of *B. filirachis* was observed during the three-year study period. Results from propagation trials using stem cuttings will be presented in a subsequent study. Vouchers mentioned in this study are deposited at KLU.

RESULTS

The inflorescences of *Barringtonia* species, such as *B. macrostachya* and *B. conoidea*, demonstrate a single growth episode strategy. In *B. conoidea*, the rachis terminates with flower buds, as shown in Figure 1A, indicating the conclusion of its reproductive growth phase. Similarly, in *B. macrostachya*, the rachis ends with a fruit, marking the completion of its growth cycle (Figure 1B). The dried tip of the rachis in *B. macrostachya*, as shown in Figure 1C, further signifies the conclusion of this growth episode. These observations illustrate the conventional single-growth episode strategy where the meristematic tip senesces, and subsequent inflorescences arise from other parts of the plant.

In contrast, *B. filirachis* exhibits episodic growth, where the same rachis undergoes multiple cycles of flowering and fruiting. As shown in Figure 2A, the inflorescences of *B. filirachis* display active flowering at the rachis tip. The rachis demonstrates distinct colour zones, with a reddish-purple section at the flower bud zone indicating dormancy (Figure 2B), and light green to green sections representing active growth and photosynthesis (Figure 2D). The white arrow in Figure 2B highlights the boundary between two distinct growth episodes, marking the end of one episode and the beginning of another. Similarly, the white arrow in Figure 2D points to the initiation of a subsequent growth phase, where new flower buds emerge from the dormant section of the rachis. Unlike species with a single growth episode, the dormant rachis tip in *B. filirachis* re-initiates growth, forming new inflorescence episodes within the same axis. This phenomenon is depicted in Figure 2C, where the white arrow marks the boundary between two distinct growth episodes. Detailed examination revealed up to four distinct growth episodes on a single rachis, indicating successive cycles of dormancy and activity. This strategy enables the rachis to serve as a prolonged reproductive structure, maintaining its capacity to support multiple growth cycles.

A similar episodic growth pattern is observed in *B. racemosa*. The first section of the rachis is green, devoid of flowers or fruits, representing the remnants of an earlier growth episode, while new flower buds emerge in the subsequent reddish section (Figure 3A). The boundary between these episodes is visually distinguishable by rachis colouration. Even after fruiting, the rachis continues to produce new flowers, as seen in Figure 3B, where mature fruits are visible on an earlier section of the rachis, while new buds form further along the same axis. In some specimens, the rachis transitions back to vegetative growth, forming axillary primordia at its tip (Figure 3C), or a rosette of leaves, as shown in Figure 3D. These transitions highlight the meristematic flexibility of *B. racemosa*.

DISCUSSION

Episodic inflorescence growth, where a single rachis undergoes multiple cycles of flowering and fruiting, is a relatively rare phenomenon among flowering plants. This study confirms the occurrence of this growth pattern in *B. filirachis* and *B. racemosa*, two species that demonstrate a unique reproductive strategy within the genus *Barringtonia*. The ability to alternate between active and dormant growth phases along the same rachis likely provides an adaptive advantage, extending the reproductive period and optimising resource use.

Both *B. filirachis* and *B. racemosa* exhibit episodic growth characterised by alternating

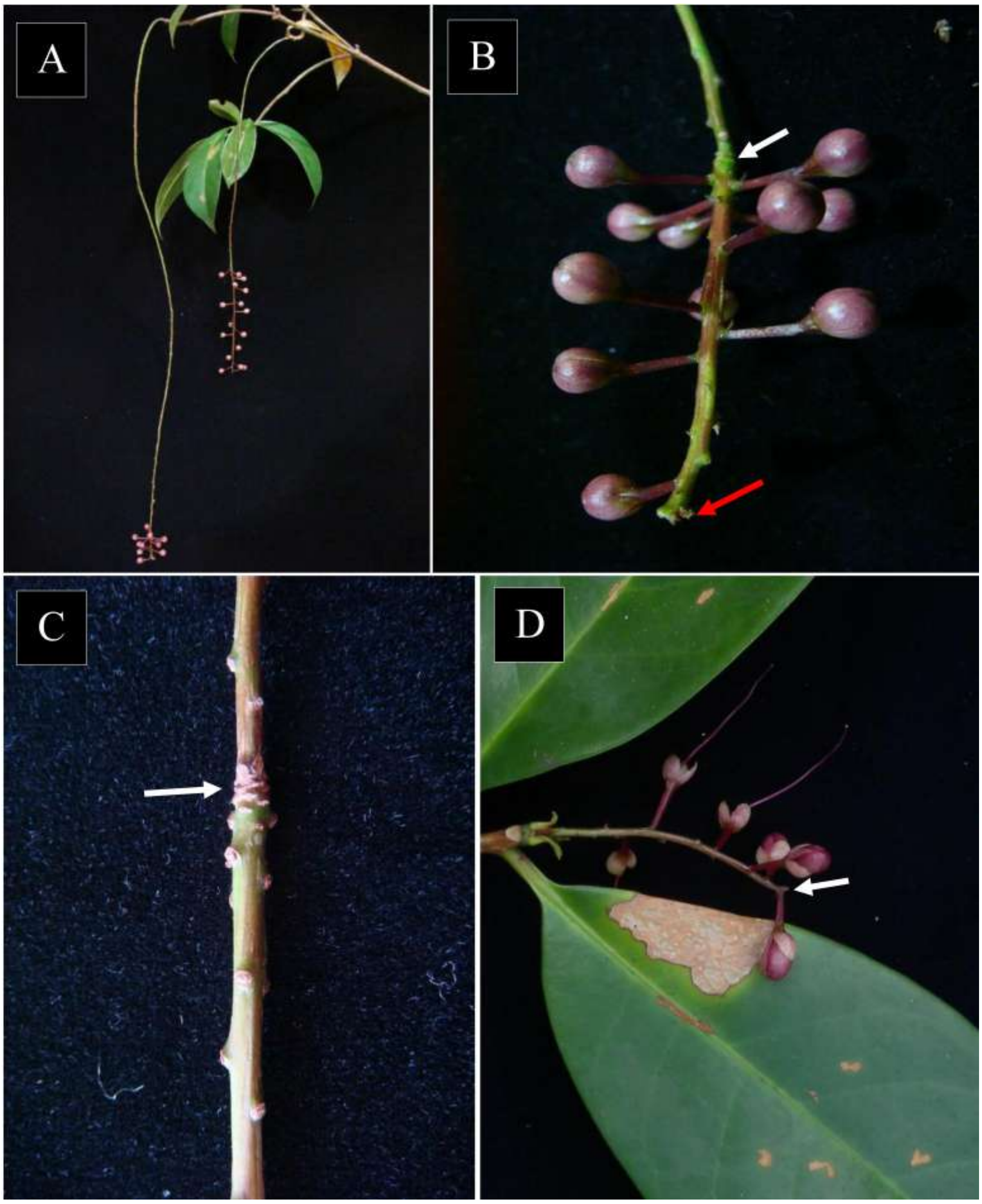

Figure 2A Inflorescences of *B. filirachis* (NSY 101), showing active flowering at the rachis tip

Figure 2B Close-up on the tip of the rachis (NSY101). The white arrow indicates the boundary between two distinct growth episodes, while the red arrow highlights a new set of primordia forming axillary to the main axis

Figure 2C Dormant tip of the rachis in *B. filirachis* re-initiating growth to form another inflorescence episode along the same rachis. The white arrow marks the demarcation between two episodes of growth

Figure 2D A single growth episode of inflorescence in *B. filirachis* (NSY 1020). The white arrow points to the initiation of a subsequent growth phase

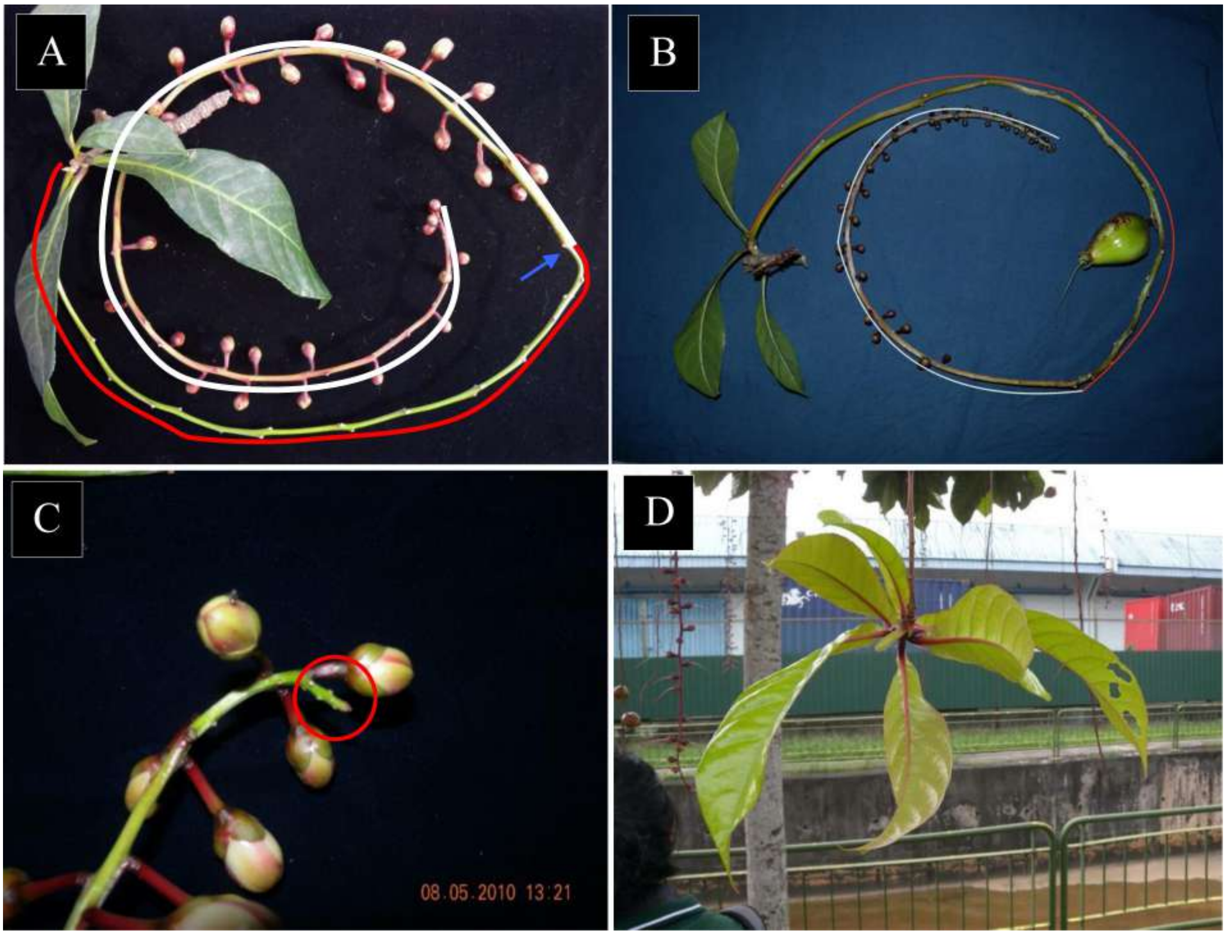

Figure 3A Rachis of *Barringtonia racemosa* (NSY 1003) showing the first growth episode (highlighted in red) without flowers or fruits, followed by the second growth episode (highlighted in white) with young flower buds. The blue arrow marks the initiation point of the second episode
Figure 3B Another example of two growth episodes in *B. racemosa* (NSY 1003). The first episode (red line) features a single mature fruit, while the second episode (white line) includes young flower buds
Figure 3C Axillary primordial formation at the end of the rachis in *B. racemosa* (NSY 999), highlighted by a red circle
Figure 3D A rosette of leaf formed at the end of rachis is *B. racemosa* (NSY 1004)

active (green) and dormant (reddish-purple) zones along the same rachis. This strategy allows for multiple flowering and fruiting cycles within a single reproductive structure, extending the reproductive period and optimising resource use. While common in *B. racemosa*, this behaviour is particularly noteworthy in *B. filirachis*, an endangered species with limited distribution in swampy lowlands. These findings suggest that episodic growth may provide an adaptive advantage in fluctuating environments, ensuring reproductive success across extended periods.

The differentiation in rachis colouration observed in both species, with light green indicating active zones and reddish-purple marking dormant zones, may play functional roles. Dormant zones could deter herbivores or pathogens, while active zones maintain photosynthetic activity. These traits appear consistent across both wild and cultivated populations of *B. racemosa* and are especially notable in the endangered *B. filirachis*, where environmental fluctuations in swampy lowlands may influence reproductive success.

Comparisons with other genera highlight the broader ecological relevance of episodic growth. For instance, *Couroupita guianensis* (*Lecythidaceae*), commonly known as the cannonball tree, exhibits successive flowering and fruiting on the same rachis, extending its reproductive period (Mori & Prance 1990). Similarly, episodic flowering has been reported in *Opuntia* (*Cactaceae*) (Nobel 1988), while genera such as *Hoya* (*Apocynaceae*) and *Gurania* (*Cucurbitaceae*) exhibit similar traits that enhance pollinator visitation and reproductive success (Jeffrey 1990, Kress & Specht 2005). These examples suggest that episodic growth is a convergent adaptation across diverse plant families.

Despite successful flowering and fruiting, the absence of seedling recruitment in *B. filirachis* over the three-year study highlights potential barriers to regeneration, including seed dispersal limitations, predation, or habitat degradation. This demonstrates the species' vulnerability and the critical need for targeted conservation efforts. Future research should investigate the genetic, ecological, and physiological mechanisms underlying episodic growth, particularly in species with restricted habitats such as *B. filirachis.*

CONCLUSION

This study highlights the ecological and conservation significance of episodic inflorescence growth in *B. filirachis* and *B. racemosa.* By alternating between phases of activity and dormancy within the same rachis, these species can sustain flowering and fruiting over extended periods, providing a reproductive advantage.

For *B. filirachis*, an endangered species confined to swampy lowlands, the lack of seedling recruitment despite successful reproduction raises concerns about its long-term viability. Conservation strategies should prioritise habitat protection and restoration while exploring alternative propagation methods, such as stem cuttings, to bolster population stability.

In contrast, the widespread distribution of *B. racemosa* demonstrates the resilience and adaptability of episodic growth across diverse environments. Further research into the genetic and ecological drivers of this reproductive strategy will deepen our understanding of its role in plant adaptation and resilience. Protecting the habitats of these species and fostering their regeneration will ensure the preservation of their unique ecological roles and contributions to tropical biodiversity.

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