

# Chronobiology of Leaf Expansion in *Victoria* 'Neverland Mumbai'

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**Abstract:** *Victoria* commonly known as the *Queen of the Pond*, is renowned not only for its enormous green circular leaves that float flat on the water surface and can bear a load along with large, white, fragrant night-blooming flowers, but also for its enormous genome surpassing 4 million base pairs roughly 1.5 times the size of the human genome. *Victoria* 'Neverland Mumbai', a novel hybrid giant water lily from the *Nymphaeaceae* family, is a perennial aquatic herb cultivated for its vast floating leaves and distinctive reproductive strategies. It flourishes in tropical, shallow, nutrient-laden waters bathed in abundant sunlight, where leaves can expand to 3 m across. This research delves into the morphological changes in leaf development, marked by initial anisotropic expansion transitioning to isotropic radial growth, exemplifying evolutionary refinements for aquatic habitats. Typical sigmoidal curves during growth provide a robust framework for mapping this growth, capturing the initial slow phase the rapid expansion period and the final asymptotic stabilization.

**Keywords:** *Victoria*, Anisotropy and Isotropy.

## I. INTRODUCTION

*Nuphar* and *Victoria* species are sporadically cultivated in ornamental pools and lakes within managed gardens, though natural populations remain rare. The *Victoria* 'Neverland Mumbai' cultivar, a hybrid developed in 2022 by hybridizers Somnath Pal and Yan Mumber and subsequently propagated by enthusiasts such as Tomas Escribano and Rich Sacher, offers critical insights into its growth patterns and environmental adaptability (Patil, 2025). The adaxial leaf surface exhibits a waxy, hydrophobic texture, deep maroon in juveniles and progressively darkening with age. The abaxial surface is reinforced by a sturdy rib network, defensive spines, and aerenchyma lacunae. These plants have evolved mechanisms to optimize photon capture, with purple pigmentation on the leaf underside facilitating enhanced light and heat absorption. Their expansive dimensions enable competitive dominance by occluding light transmission through the water column, thereby suppressing submerged aquatic flora. This study investigates the distinct circadian rhythms governing leaf elongation and development, drawing parallels to the established day-night oscillating patterns observed in other botanical models (Ferrario *et al.*, 1992). As annuals, *Victoria* cultivars require annual reseeding in warm water with sufficient space for expansion. In winter, they display characteristic plate formation, a distinctive trait derived from the parental *V. amazonica* in *Victoria* 'Neverland Mumbai'.

## II. METHODOLOGY

In September 2025, daily measurements of leaf dimensions were conducted at predetermined intervals at Kavivarya Moropant Botanical Garden, Tuljaram Chaturchand College, Baramati, until the leaves of *Victoria* 'Neverland Mumbai' attained a stable circular, plate-like morphology. Length and breadth were recorded at successive time points.

Leaf surface area was calculated using the formula

$$\text{Leaf Surface Area} = \text{Length} \times \text{Breadth} \times 0.517.$$



**III. RESULTS**

Daily measurements conducted at consistent intervals revealed that leaves of *Victoria* ‘Neverland Mumbai’ exhibit rapid expansion characterized by a distinctive developmental trajectory (Table 1, Graph 1). Initially, the leaves display a biconvex form and curl inward while submerged. Upon emergence above the water surface, they transition to a rounded morphology. Early growth is marked by greater length relative to breadth; however, by the sixth day (120 hours), length equals breadth, after which breadth surpasses length, culminating in a fully circular shape. Concurrently, during maturation, the abaxial ribs thicken and strengthen, while leaf margins upturn slightly. Initial rapid growth decelerates at maturity, with rim formation stabilizing the plate-like structure, enabling flotation and load-bearing capacity on the water surface.

This ontogenetic progression from rapid early expansion to slower maturation demonstrates an initial anisotropic phase yielding to isotropic radial growth, yielding a stable, circular lamina optimized for aquatic flotation. Rib reinforcement and rim development underscore adaptive enhancements for buoyancy and structural integrity. Integrating these morphogenetic patterns into a mathematical framework requires shifting from static morphological observation to the application of differential equations that capture the shift from anisotropic to isotropic expansion rates. By leveraging sigmoid-based growth functions, we can effectively parameterize the temporal acceleration of leaf area expansion, thereby bridging the gap between observed developmental phases and predictive mechanistic modeling (Rein *et al.*, 2011). Ultimately, these mathematical representations provide a robust quantitative foundation for understanding how *Victoria* species navigate the energetic constraints of their aquatic environment through precise, rate-regulated growth (Liu *et al.*, 2018). Future inquiries might employ multi-sigmoidal models to better account for the complex, non-linear transitions inherent in these expansive leaf morphologies (Crescenzo *et al.*, 2020). By calibrating these non-linear growth dynamics, researchers can further quantify the adaptive bio-energetics that permit *Victoria* leaves to optimize photosynthetic output while maintaining structural integrity against surface water turbulence (Putra *et al.*, 2025). Overall, the growth pattern of *Victoria* ‘Neverland Mumbai’ leaves exemplifies a precise integration of morphology, function and environmental adaptation. Such modeling serves as a critical bridge between genetic potential and morphological phenotype, elucidating how precise, time-dependent growth strategies allow these giant aquatics to dominate their niche. These mathematical representations provide the essential quantitative foundation for understanding the rate-regulated growth and adaptive resilience of *Victoria* ‘Neverland Mumbai’.

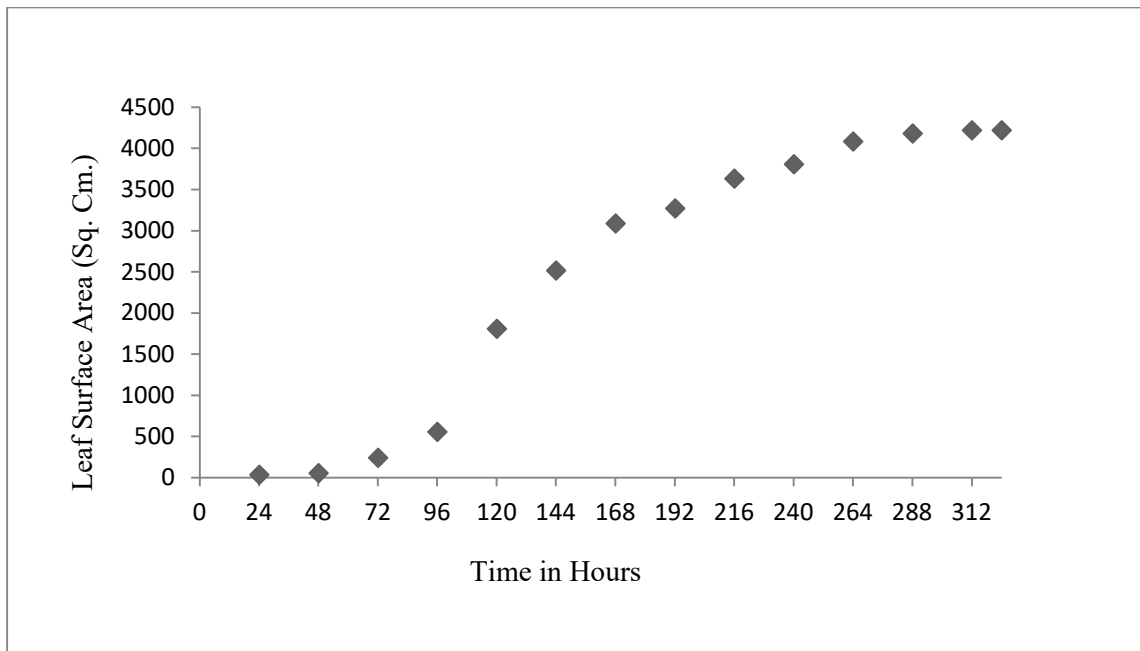
**Table(1): Leaf surface area of *Victoria* ‘Neverland Mumbai’ at different time intervals.**

S. No.	Time (Hrs)	Length (Cm)	Breadth (Cm)	Surface area (Sq.cm)
1	0	14	7.5	54.28
2	24	17	10	87.89
3	48	20.1	10.5	107.03
4	72	27	21	293.13
5	96	42	28	607.99
6	120	60	60	1861.2
7	144	69	72	2568.45
8	168	76	80	3143.36



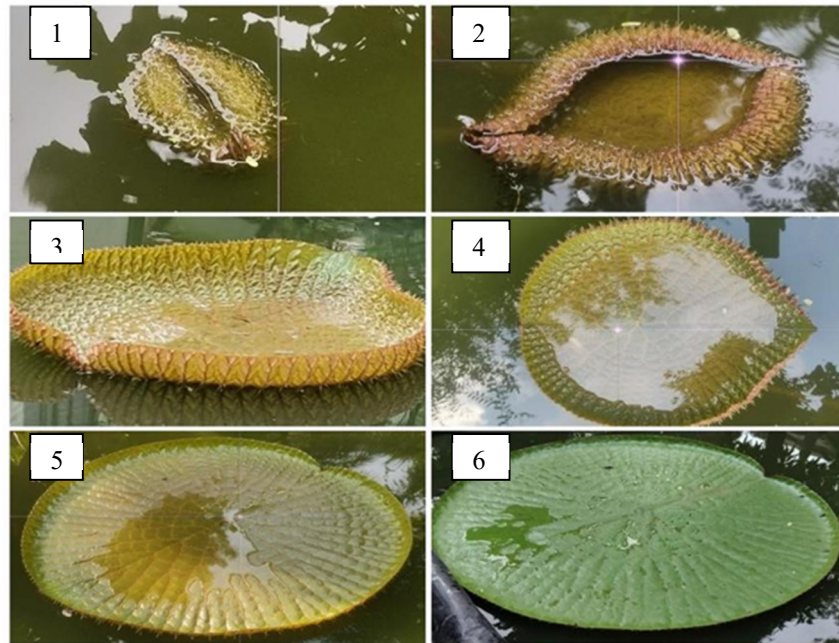
9	192	80	80.4	3325.34
10	216	80.6	88.5	3687.81
11	240	90	83	3861.99
12	264	92	87	4138.06
13	288	94	87	4233.42
14	312	95	87	4273.05

**Graph 1: Sigmoidal Expansion Kinetics of *Victoria* ‘Neverland Mumbai’ Leaves**



**Photoplate 1 : Different phenophases of leaf in *Victoria* ‘Neverland Mumbai’**





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