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Environmental Factors and Management Strategies Influencing Sungkai (*Peronema canescens* Jack.) Population Dynamics in City Forest, West Wales, Universitas Indonesia Campus, Depok

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Abstract: Sungkai (*Peronema canescens*), commonly used as an ornamental plant for household demarcation due to its aesthetic appeal, also offers medicinal benefits, effectively utilized in treating diverse ailments encompassing diseases, infections, and inflammations. This study aims to investigate the population dynamics and growth parameters of sungkai in the City Forest, West Wales, Universitas Indonesia Depok, we are focusing on various environmental factors and management practices affecting their development. Measurements of light intensity, temperature, humidity, soil pH, moisture, and wind speed were conducted to assess their impact on sungkai growth. The acquired data undergoes analysis through established formulas, and the outcomes are depicted in diagrams and tables. Results revealed congruence in altitude and light intensity with ideal growth conditions, while discrepancies in air humidity, soil pH, and moisture posed potential limitations to sungkai plant development. Analysis of sungkai tree diameters showcased varied growth rates, possibly influenced by plant spacing and nutrient competition. Furthermore, proposed intensive care practices such as pruning, thinning, and pest management are suggested as vital strategies to optimize sungkai growth. Overall, addressing these environmental factors and employing suitable management practices could significantly contribute to sustaining and enhancing the sungkai population within the City Forest, West Wales, Universitas Indonesia Depok.

Keywords: Environmental factors; Management strategies; *Peronema canescens*; Population dynamics; UI City Forest

Introduction

The UI City Forest, positioned on the cusp of South Jakarta and Depok City, serves as a pivotal green expanse with significant ecological relevance within the region. Recognized as a Conservation City Forest following the Governor of DKI Jakarta's decree in 2004, this green space spans approximately 90 hectares, contributing to the larger 312-hectare campus area (Waryono, 1990). Its multifaceted environmental advantages encompass vital roles such as providing ventilation, acting as the lungs of the city, mitigating pollution, curbing erosion, dampening noise, conserving germplasm, nurturing diverse animal habitats, and enhancing the city's aesthetics (Samsoedin & Waryono, 2010).

The UI City Forest comprises three primary sectors: Natural Vegetation, East Wales, and West Wales. The West Wales segment specifically showcases flora indigenous to the region, encompassing plant species

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from areas like Sumatra, Java, and Kalimantan. Notably, various tree varieties, including the sungkai (*Peronema canescens* Jack.), have been intentionally cultivated within the West Wales portion of the UI City Forest.

Sungkai, belonging to the Lamiaceae family, stands as a quintessential Indonesian plant thriving primarily in southern Sumatra and Kalimantan (Ningsih et al., 2013). Its geographic presence extends across Malaysia, Sumatra, Kalimantan, Banten, and West Java. Typically flourishing in tropical rainforests, sungkai thrives in dry to slightly moist soil, often found within altitudes ranging from sea level to 600 meters (Ningsih et al., 2013). Exhibiting a woody nature, this tree reaches heights of up to 15 meters with a trunk thickness of approximately 60 centimeters (Halim et al., 2020). Given its significance in construction, furniture crafting, and medicinal applications, preserving the existence of sungkai remains paramount.

Sungkai serves multifaceted purposes, commonly employed as an ornamental plant for household demarcation. Beyond its aesthetic value, it possesses medicinal properties drawn from its leaves and bark. These components are harnessed in the treatment of various ailments, including diseases, infections, and inflammations (Ibrahim & Kuncoro, 2012; Ahmad & Ibrahim, 2015).

While sungkai historically was not part of the traditional medicinal plants used by the Dayak Kanayatn Ahe Ethnic in Landak Regency, West Kalimantan (Patiola et al., 2023), it holds significance as the Dayak tribe in East Kalimantan incorporates sungkai leaves into traditional medicine (jamu), effectively treating fever, influenza virus infections, stomach discomfort, and serving as an antibacterial agent for oral and skin care (Maigoda et al., 2022). Similarly, Rahman et al. (2021) documented its usage in Jambi where locals traditionally employ a blend of sungkai leaves to manage fever, malaria, seizures in children, postpartum recovery, and counteract poisoning. However, Yelianti et al. (2023) did not include sungkai as a medicinal plant used by Suku Anak Dalam (SAD) in Nyogan Village, Jambi Province. Moreover, East Lampung residents utilize it as a remedy for jaundice and as a body freshener (Evizal et al., 2013).

Scientific research has also indicated the diverse efficacy of sungkai's extract, demonstrating its activity as an antimalarial, antibacterial agent, and exhibiting in vitro photo-cytotoxic activity through a cell viability test using the human leukaemia cell-line HL60 (Ong et al., 2009; Ningsih & Ibrahim, 2013; Ningsih et al., 2013; Putranto, 2014; Kusriani et al. 2015; Ramadenti et al., 2017; Prasiwi et al., 2018; Fransisca et al., 2020). Additionally, sungkai extract has shown promise in improving diabetes-associated factors in 3T3-L1 adipocytes, and functioning as an immunostimulant (Khattaka et al., 2013; Yani et al., 2014; Dillasamola et al., 2021; Yudha et al., 2021; Okfrianti et al., 2022; Ong et al., 2022; Tias et al., 2022; Irnameria & Okfrianti, 2023).

Our ongoing research, focusing on metabolomics and chemical ecology, aims to delve deeper into the metabolomics and bioactivity of sungkai leaf extract as an immunomodulator, particularly from specimens growing within the UI campus. Previous studies by Kitagawa et al. (1994), Simanjuntak (1996), and Halim et al. (2020) have conducted phytochemical screening and isolated bioactive compounds from sungkai's extract. To accomplish this, it is vital to acquire initial data concerning the sungkai plant population. Mr. Taryana, an expert at the Biology Department of FMIPA UI, noted that the sungkai plants at UI were originally part of a reforestation program carried out in the early 1990s (Personal communication, 2023).

Preliminary observations conducted in the West Wales region of the UI City Forest reveal that sungkai plants in this area have not received adequate maintenance practices like pruning or thinning. This lack of care emphasizes the necessity for a detailed population analysis, focusing specifically on the sungkai population's structure. Such an analysis is crucial to comprehend the current state and conditions of sungkai plant populations within their habitat. As Odum (1993) defines it, a population consists of organisms of the same species living within a specific area. Hardiansyah (2010) further elucidates that population structure encompasses various elements, including distribution patterns, density, plant demography, stage and age distribution, fecundity, as well as age structure and stages. Gaining insights into these factors is imperative in crafting precise preservation strategies aimed at safeguarding and perpetuating the sungkai plant population within the UI City Forest.

Given the aforementioned context, it becomes imperative to conduct comprehensive research on the population study of sungkai (*P. canescens* Jack.) within the UI City Forest's West Wales area. The primary objective of this research is to meticulously investigate and analyze the population dynamics of sungkai (*P. canescens* Jack.), specifically within the West Wales region of the UI City Forestresults.

Method

The research was conducted in March 2023 within the West Wales City Forest of the University of Indonesia (UI), precisely at coordinates 06º21´13.9″S and 106º49´40.3″E, with an elevation of 98 meters above sea level (masl). Various tools were employed for this study, including GPS, raffia rope, roll meter, thermometer, hygrometer, luxmeter, anemometer, and writing instruments. The research methodology employed a survey approach within the area where sungkai trees were located, utilizing the plotted line method. The determination of sample plots was achieved through the implementation of Purposive Systematic Sampling.

The observation technique involved segmenting the West Wales section of the UI City Forest, specifically housing sungkai plants (*Peronema canescens*), into a defined area measuring 100 meters in length and 20 meters in width. Within this area, it was divided into 5 points, each measuring 20 meters by 20 meters. For the observation process, quadrants were designated based on the developmental stages of the sungkai trees. The quadrant size for observing mature trees was set at 20 meters by 20 meters, while for the pole phase, observations were conducted within areas measuring 10 meters by 10 meters. Additionally, for the weaning phase, the observation quadrants were smaller, measuring 5 meters by 5 meters.

The process for examining the population structure entails several key steps. Firstly, the identification of the research location involves utilizing GPS (Global Positioning System) to precisely determine the specific area within the West Wales zone of the UI City Forest where sungkai plants are situated, marked accordingly on an allocated map. Secondly, the establishment of observation points necessitates the creation of five systematically determined points, each spanning 100 meters in length and 20 meters in width, strategically positioned within the designated area. Subsequently, the population analysis phase involves thorough assessments and calculations for each identified sample, categorizing them based on their developmental stages, specifically into three distinct categories: trees (diameter ≥ 20 cm), poles (diameter: 10 - 20 cm), and saplings (diameter < 10 cm and height > 1.5 m). Lastly, environmental parameter measurements are conducted at two different locations within the research site: one at the plot's centre and another at the plot's edge, closer to the nearby lake. The parameters recorded include air temperature, air humidity, soil pH, soil moisture, soil temperature, light intensity, and wind speed.

This structured approach ensures systematic and comprehensive observations, enabling a detailed analysis of the sungkai plant population's structure and its corresponding environmental conditions within the designated research area. The assessment of plant vegetation structure involves analyzing density, which reveals the count of individuals for each species within the sample plot. The density of each plant age level is determined through a specific calculation method:

$$\text{Density (D)} = \frac{Number\ of\ individuals\ of\ a\ specific\ plant\ age\ level}{Area\ of\ the\ sample\ plot\ (ha)} \quad (1)$$

As per Odum (1993), the population structure pyramid encompasses three main forms: A pyramid characterized by a broad base, indicating a population in the growth phase; Bell-shaped polygons that signify stationary populations; A jug or vase-shaped pyramid, symbolizing a declining population.

To derive the average diameter value, employ the following formula:

$$\bar{x} = \frac{\sum x}{n} \quad (2)$$

Notes:
$\bar{x}$: average value
$\sum x$: the number of individual values of the diameter parameter
N : number of individual observations

The following formula was used to compute the standard deviation:

$$sd = \frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1} \quad (3)$$

Notes:
sd : standart of deviation
x : diameter
n : number of trees

The coefficient of variation was determined using the following formula (Nugroho, 2008):

$$CV = \frac{sd}{\bar{x}} \quad (4)$$

Notes:
CV : coefficient of variation
Sd : standard of deviation
$\bar{x}$: average diameter

The criteria for coefficient of variation are as follow:
CV : 1-10% (low)
CV : 10-20% (medium)
CV : 20-30% (high)
CV : > 30 % (very high)

Result and Discussion

Result

The findings from the research on the population structure of the sungkai plant, *Peronema canescens* Jack, in the West Wales section of the UI City Forest, covering an area of 100 meters by 20 meters, revealed the following population structure:

Table 1. Structural Analysis of Sungkai Plant Population in West Wales, UI City Forest

Structure	Number of individuals	Density (individual/m²)	Density (individual/ha)
trees (20m x 20m)	46	0.02	230
poles (10m x 10m)	5	0.003	25
saplings (5m x 5m)	2	0.001	10
Sum	53	0.03	265

Following the investigation into the population structure of sungkai plants in the West Wales section of the UI City Forest, spanning an area of 100 meters by 20 meters, the outcomes are depicted in Figure 1. Meanwhile, a sequence of numbers reflecting the age pyramid will exhibit a pyramid-shaped structure akin to Figure 2.

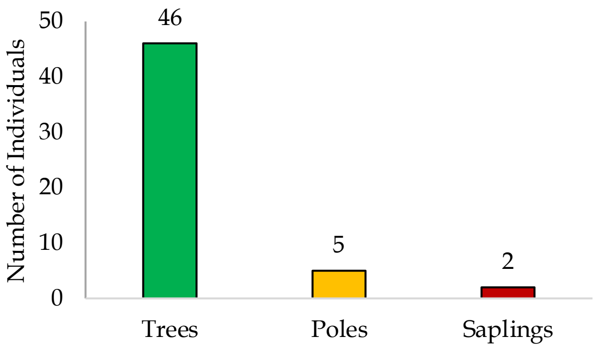

Figure 1. Population structure of sungkai plants in the West Wales section of the UI City Forest

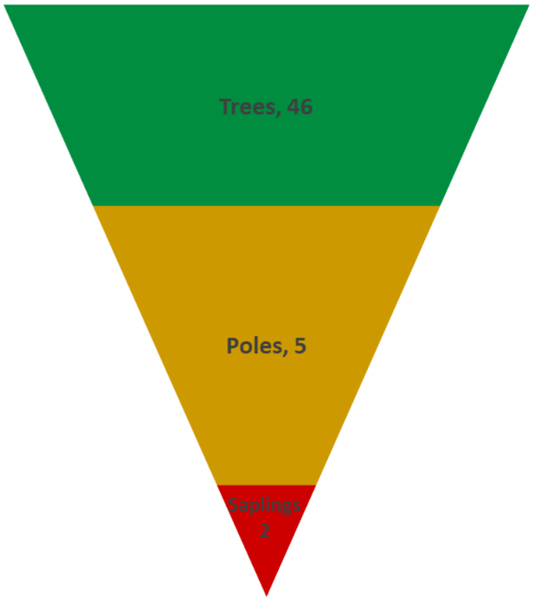

Figure 2. The age pyramid of population structure of sungkai plants in the WEST WALES section of the UI City Forest

The recorded environmental parameter measurements conducted in the West Wales area of the UI City Forest are presented in Table 2 and the gathered data regarding the diameter measurements of sungkai plants are presented in Table 3.

Table 2. Environmental Parameter Measurements: West Wales Area, UI City Forest

Environmental parameter	Location I (in the middle of the plot)	Location II (near lake)
Air temperature	28.5	29.1
Air humidity	75.70%	76.20%
Wind speed	0.51 m/s	0.10 m/s
Soil's pH	5.6	6
Soil humidity	50%	30%
Light intensity	2800 lux	3900 lux

Table 3. Diameter Measurements of Sungkai Plants in West Wales, UI City Forest

Variable	Average	SD	CV%
Diameter (cm)	54.70	24.03	43.93

Discussion

The analysis of sungkai plant population structure within the West Wales area of the UI City Forest reveals a higher count of individual trees compared to individual poles and saplings, as illustrated in Figure 1. The findings indicate a density of 230 individuals per hectare for trees, 25 individuals per hectare for poles, and 10 individuals per hectare for saplings. The noticeable disparity in population density between trees, poles, and saplings suggests that while trees adapt well to environmental conditions, their growth phase significantly slows down in terms of flowering and seed production.

The process of regeneration can be influenced by various factors such as natural processes involving seed dispersal, successful seed germination, or vegetative regeneration through cuttings or layering. Imelda et al. (2007) note that sungkai plants only flower 1-2 times a year, impacting the regeneration cycle and potentially contributing to the observed differences in population density among different developmental stages of sungkai plants. Sungkai trees exhibit varying fruiting and flowering seasons contingent upon their geographical distribution. In Java, flowering typically occurs during June and July. In South Sumatra, fruit-bearing transpires throughout the year, primarily from March to June, while in Kalimantan, it spans from January to February. Generally, the appearance of fruit follows approximately two months after the flowering season.

Sungkai seeds pose challenges in germination, boasting a mere 30% germination rate. Consequently, propagation is primarily achieved vegetatively through cuttings (Wilarso, 2000). This method of propagation disrupts the natural regeneration cycle of sungkai plants, potentially leading to an accumulation of individuals in the tree phase. The significant disparity in population density between the tree phase and the pole and sapling phases results in an accumulation of these latter stages within the tree phase. Vulnerability to environmental factors affects the pole and sapling phases, leading to a diminished count compared to the tree phase. This discrepancy is attributed to the tree phase's ability to create a denser canopy, which limits the available space and modifies light penetration below. Moreover, trees have enhanced access to essential resources like water and nutrients, fostering their superior growth and resource competition compared to lower phases (Sari & Aulya, 2022).

This observation aligns with Wati's perspective (2010), suggesting that the uneven distribution of sungkai plants stems from varying access to growth-supporting resources, such as light and nutrients, dictated by environmental factors. Additionally, competition among populations or with other plant species could contribute to a decline in the sungkai population. Furthermore, environmental factors play a crucial role in impeding sungkai seeds from developing into seedlings. Wahyuni et al. (2017) posit that factors influencing the growth of tree saplings, such as sunlight availability and soil attributes including nutrients, physical, and chemical properties, significantly impact seedling growth.

The reproductive status of a population can be discerned by analyzing the age-based population structure. In the case of sungkai plants, the population structure reveals a "pasu" or vase-shaped pyramid, as depicted in Figure 2. This shape denotes a greater abundance of individuals in the tree phase compared to the weaning and pole phases, signifying a decline in the sungkai plant population.

According to Odum (1993), population structures are categorized into pyramids with wide bases representing growing populations, bell-shaped polygons indicating stable populations, and jugs or vases indicating declining populations. The findings from this research indicate that the sungkai population structure in the West Wales area of the UI City Forest mirrors a kendi or vase-shaped pyramid. This configuration highlights a higher percentage of individuals in the mature age group compared to the younger age group, suggesting that the sungkai plant population is at risk or facing a decline. Environmental factors are likely influential in shaping the condition of the pasu pyramid.

Various factors influence population structure, with environmental factors playing a significant role. The results obtained from environmental parameter measurements, detailed in Table 2, indicate that air temperature ranged from 28.5° to 29°C. This temperature range aligns with the optimal growth conditions for sungkai, as affirmed by Wilarso (2000), who noted that sungkai thrives in monthly temperatures between 21°C and 32°C. However, the air humidity measurements in the West Wales area of the UI City Forest ranged from 75.70% to 76.20%, deviating from the suitable humidity levels for sungkai growth. According to Wati (2010), the ideal air humidity range for plants within the *Peronema* genus, which includes sungkai, is between 84% and 92%. Humidity serves as a critical factor influencing sungkai plant growth.

The disparity between the measured air humidity and the optimal range identified by Wati (2010) suggests that humidity could be a limiting factor affecting sungkai growth in the UI City Forest area of West Wales. This discrepancy emphasizes the potential impact of environmental factors, specifically air humidity, on sungkai plant development within this region.

The measured wind speed parameters ranged from 0.10 m/s to 0.51 m/s within the West Wales region of the UI City Forest. Setiono et al. (2015) mentioned that wind speeds exceeding 0.58 m/s can potentially impact plant growth and lead to physical damage. High wind speeds might cause harm to plant inflorescences, resulting in premature shedding of flowers before completing pollination. Consequently, these flowers fail to develop into fruits and seeds.

In the context of the UI City Forest area in West Wales, the recorded wind speed parameters remain within acceptable limits, as they fall below the threshold identified by Setiono et al. (2015) as potentially detrimental to plant growth. This observation suggests that the measured wind speeds, within their current range, do not pose an immediate threat to sungkai plants' reproductive processes within this region.

The soil pH measurements conducted in the UI City Forest area of West Wales revealed a pH range between 5.6 and 6. These findings diverge from the ideal soil pH range for sungkai plants, as specified by Wilarso (2000), which should ideally fall between 6.6 and 7. This discrepancy suggests that soil pH might serve as a limiting factor in sungkai plant growth within the UI City Forest area in West Wales.

Additionally, the recorded soil moisture measurements within this area ranged from 30% to 50%. However, these readings do not align with the optimal moisture levels required for plant growth, which, according to Polunin cited in Setiono et al. (2015), should ideally range between 60% and 100%. The observed discrepancies in soil pH and moisture levels indicate potential limitations in these environmental factors that could impede sungkai plant growth in the UI City Forest area of West Wales. The unsuitable soil pH and moisture levels might adversely affect the ability of sungkai plants to thrive in this region.

The light intensity plays a crucial role in enhancing the photosynthetic process of plants, fostering increased productivity and accelerated growth (Saputri et al., 2023). Measurement conducted in the West Wales region of the UI City Forest revealed light intensity ranging from 2800 lux to 3900 lux, suggesting favorable conditions for sungkai plant growth. Wati (2010) suggests an optimal light intensity ranging between 3100 lux and 10500 lux for plants belonging to the *Peronema* genus, which includes sungkai.

Moreover, the elevation of the West Wales area in the UI City Forest, standing at 98 meters above sea level, complies with the requirements for successful sungkai growth. Wilarso (2000) affirms that sungkai thrives well at altitudes ranging from 0 to 600 meters above sea level, favoring red and yellow podzolic soil. However, despite these favorable conditions, several environmental factors crucially impact sungkai plant growth. The studied environmental parameters reveal that certain factors act as limitations for sungkai growth, specifically air humidity, soil pH, and soil moisture. These factors exhibit parameter values that do not align with the optimal requirements for sungkai plant growth, potentially hindering their development within the area.

Tree diameter serves as a crucial dimension for assessing tree potential. The average tree diameter measurement from Table 2 stands at 54.696 cm, with a standard deviation of 24.026 and a coefficient of variation of 43.926%. The obtained coefficient of variation exceeds 30%, categorizing it as "very large." This magnitude suggests a highly diverse or varied growth rate concerning tree diameter within the sungkai trees. The substantial variation in diameter is evident in the research area, where sungkai trees exhibit both large and small diameters, underscoring the considerable diversity in their growth patterns.

Suboptimal growth in plant diameter within this location may result from competition among plants for acquiring nutrients. Plant competition refers to a scenario where the growth of one plant is impeded by interactions with other neighboring plants. It occurs when multiple plants share similar growth requirements but face limitations in their environment to fulfill those needs adequately. This competition among plants significantly influences and hampers their growth dynamics (Sandalayuk et al., 2023).

Plant spacing significantly influences plant diameter growth. In open areas, plant diameter growth is anticipated to be more rapid compared to shaded areas, resulting in a positive impact on diameter expansion. This aligns with the assertion made by Mawazin et al. (2008) that wider planting distances correlate with larger diameters, whereas closer planting distances are associated with smaller diameters. The rationale behind this relationship lies in the reduced competition for nutrients when fewer trees are present in wider planting distances. Consequently, wider spacing diminishes the competition among plants for essential nutrients. Additionally, wider plant spacing augments the openness of the plant canopy, facilitating increased sunlight absorption crucial for photosynthesis processes.

In addition to manipulating plant spacing to influence light intensity and nutrient availability, plant growth can also be managed through intensive care practices. Intensive care primarily involves pruning and thinning techniques. Ensuring the elimination of pests from staple plants is imperative to optimize their growth potential. Thinning, an essential aspect of intensive care, involves selectively removing undesired or poorly growing trees (Sandalayuk et al., 2023). This process creates an ideal growth environment by providing ample space for the growth of desired plants (Thamrin, 2020).

Conclusion

In conclusion, the growth and population dynamics of sungkai plants in the West Wales area of the UI City Forest are influenced by a multitude of environmental factors. While factors like light intensity and altitude align well with optimal growth conditions, discrepancies in parameters such as air humidity, soil pH, and soil moisture suggest potential limitations affecting sungkai plant development. The diverse diameters observed among the sungkai trees indicate a varied growth rate, likely influenced by factors like plant spacing and competition for nutrients. Intensive care practices like pruning, thinning, and pest management could play a pivotal role in optimizing sungkai plant growth by regulating plant spacing and providing a conducive environment for desired plant development. Addressing these factors collectively can contribute significantly to the overall health and sustainability of the sungkai plant population in the UI City Forest, West Wales.

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Author Contributions

Collecting data, A.S.H.N., Y.Y.; formal analysis, A.S.H.N., Y.Y.; writing original draft article, A.S.N.H.; Conceptualization, Y.Y.; reviewing, Y.Y.; editing, Y.Y.; supervision, Y.Y.; and funding acquisition, YY. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest
The authors declare no conflict of interest.

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