International Journal of Ecophysiology
Journal homepage: https://talenta.usu.ac.id/ijoep

Assessing Environmental Drivers of the Distribution of the Rare Species *Johannesteijsmannia altifrons*: a literature review

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ARTICLE INFO
Article history:
Received 20 October 2024
Revised 10 January 2025
Accepted 24 February 2025

E-ISSN: 2656-0674

How to cite:
Aulia Juanda Djaingsastro, Etti Sartina Siregar (2025), "Assessing Environmental Drivers of the Distribution of the Rare Species Johannesteijsmannia altifrons: a literature review". *International Journal of Ecophysiology*, (7)1, 24-30.

Http://doi.org/10.32734/ijoep.v7i1.19062

ABSTRACT
Johannesteijsmannia altifrons, a palm species exhibits unique dispersal mechanisms and distribution patterns that are critical to understanding its ecological dynamics. Dispersal has a significant impact on this species' spatial distribution and population dynamics. The distribution is significantly influenced by altitude, which affects its growth and habitat suitability. Publications and references in this analysis came from scientific articles published in bibliographic databases such as Scopus and Google Scholar. The keyword search used was "*Johannesteijsmannia altifrons*". The authors examined the literature related to the subject of the systematic review, assessed methodological rigor, analyzed the results being reported in the selected studies. Condensed and organized the data before incorporating the findings into a comprehensive systematic review in narrative form. The distribution of *J. altifrons* in Indonesia is mainly in the Sumatra region, especially in the Northern and Central parts of the island. Taman Nasional Gunung Leuser (TNGL), Bukit Bungkuk Nature Reserve Forest and the surrounding lowland forests are good habitats. This species has habitat suitability at range elevations 20-500 meters (asl), very steep slopes (≥ 45%). Optimal growth occurs under tree canopies, which provide the necessary shade for the plant to thrive. This suggests a specific habitat preference that influences its distribution
Keyword: *Johannesteijsmannia altifrons*, Ecosystems, Rare Species.

ABSTRAK
Johannesteijsmannia altifrons, spesies palem yang memiliki mekanisme penyebaran dan pola distribusi yang unik yang sangat penting untuk memahami dinamika ekologisnya. Penyebaran memainkan peran penting dalam membentuk distribusi spasial spesies ini, yang mempengaruhi dinamika populasi. Penyebaran secara signifikan dipengaruhi oleh ketinggian, yang mempengaruhi pertumbuhan dan kesesuaian habitat. Publikasi dan referensi dalam analisis ini berasal dari artikel ilmiah yang dipublikasikan di database bibliografi seperti Scopus dan Google Scholar. Kata kunci pencarian yang digunakan adalah "*Johannesteijsmannia altifrons*". Para penulis memeriksa literatur yang terkait dengan subjek tinjauan sistematis, menilai ketelitian metodologis, menganalisis hasil yang dilaporkan dalam studi yang dipilih. Memadatkan dan mengorganisir data sebelum menggabungkan temuan-temuan tersebut ke dalam tinjauan sistematis yang komprehensif dalam bentuk naratif. Penyebaran J. altifron di Indonesia sebagian besar berada di wilayah Sumatera, terutama di bagian Utara dan Tengah pulau tersebut. Taman Nasional Gunung Leuser (TNGL),

Hutan Suaka Alam Bukit Bungkuk dan hutan dataran rendah di sekitarnya merupakan habitat yang baik. Spesies ini memiliki kesesuaian habitat pada rentang ketinggian 20-500 meter (dpl), lereng yang sangat curam (≥ 45%). Pertumbuhan optimal terjadi di bawah kanopi pohon, yang menyediakan naungan yang diperlukan bagi tanaman untuk berkembang. Hal ini menunjukkan preferensi habitat spesifik yang mempengaruhi distribusinya
Keyword: *Johannesteijsmannia altifrons*, Ekosistem, Spesies Langka.

1. Introduction

Johannesteijsmannia H.E. Moore is a genus in the tribe Corypheae Mart, subfamily *Coryphoideae* Griff. (*Arecaceae*), found in the tropical rainforests of southern Thailand, Malaysia and Indonesia [1]. The first species of *Johannesteijsmannia* was discovered by Johannes Elias Teijsmann (1808–1882, a Dutch botanist) during his expedition to the west coast of Sumatra from 1856–1857. This was described in the volume 28 of *Linnaea* as *Teysmannia altifrons* Reichb.f. et Zoll. in 1858 by Reichenbach and Zollinger. They suggested the palm should be placed next to *Salacca* and *Wallichia* and not far from *Nypa*. In 1868, Miquel made a more comprehensive description based on more material and suggested that palms were closer to Coryphoideae than Salacca, Wallichia, and Nypa. [1,2]. *Johannesteijsmannia altifrons*, a critically rare plant endemic to specific tropical regions, serves as a compelling case study in understanding how environmental drivers shape biodiversity. Indonesia has a plan to conserve all of plant species listed in IUCN category in new developed botanical gardens by 2010 to achieve the target that 60% of threatened plant species be conserved through ex situ collection [3].

Johannesteijsmannia is a palm genus of four tropical rain forest understorey species. Only *J. altifrons* is widespread, ranging from southern Thailand, Peninsular Malaysia, Sumatra to western Borneo while *J. lanceolata, J. magnifica and J. perakensis* are endemic to Peninsular Malaysia. *Johannesteijsmannia altifrons*, also known as Joey palm or "Daun Payung" or "Daun Sang" in local languages in Malaysia and Indonesia. It refers to the genus and is identified primarily by its enormous diamond-shaped to extremely broad, upright leaves. *Johannesteijsmannia altifrons* Trees can develop up to 10 – 20 ft tall and 10 - 15 ft wide. A medium measured, trunkless palm with huge, straightforward, unified clears out that can be up to 6 m in length, coming straightforwardly from an underground root-stock [2].

However, it is fairly challenging to grow outside of ideal tropical circumstances because to its requirement for high humidity and shade. The leaves are also used in some local communities for a variety of customary uses, like making crafts or temporary roofs. However, excessive leaf harvesting for these uses may result in notable population decreases.

The distribution of *J. altifrons* is influenced by habitat suitability factors such as slope and elevation, particularly within the Sei Betung resort area [4]. Due to the low population distribution of this species, mapping efforts were made using GIS in secondary forests, so a conservation strategy is needed [4]. The geological history and the condition of the ecosystem are among the factors influencing the distribution patterns, as well as the morphological and genetic variations of the widespread species [5]. During the past ten years, loss and degradation of forest habitats are less attributed by illegal logging. The Permanent Reserved Forests (PRF) network's producing forests do not spare populations from logging damage. The growth of extensive spaces in the forest canopy and the loss of forest structure during logging might damage *Johannesteijsmannia*, either directly or physically [6]. Forest areas are being rapidly and extensively converted to agricultural usage, in particular for oil palm plantations as well as pulp and paper industry are the major driving forces [3,7].

People have traditionally employed plant parts, extracts, and complex products to cure illness, as medications and cosmetics, and in both conventional and modern ways [8-12]. At Tanjung Pura on the Batang Serangan North Sumatra discovered the leaves of *Johannesteijsmannia altifrons* where used as roof [2,13]. Three factors that greatly affect the intensity of utilization of the Leaf (1) income, (2) counseling, understanding of *J. altifrons* [14]. Their increasing commercial exploitation as ornamental plants makes conservation a priority [9]. Explore the bioactive compounds of *J. altifrons* for potential pharmaceutical applications, which could also add value to the conservation efforts by highlighting the species' economic importance [15]. This sort of leaf has a unique feature in that it is supported by a single main stem, which can be used in architectural and structural designs.

In view of the limited distribution of *J. altifrons* species and their sensitivity towards forest disturbance, the conservation of this genus is highly desired before it is too late. Knowledge of the levels and patterns of genetic diversity within a population as well as genetic differentiation between populations is crucial for

developing conservation strategies [9,16,[17]. Although *J. altifrons* is more widespread and common than the others, it should also be considered under threat. Field observations in Belum Forest, Perak over a ten-year period suggested that the native population of *J. altifrons* have decreased to approximately a quarter of the original population (Lim and Whitmore, 2000)

The exploration of plant distribution within specific ecological contexts serves as a vital area of biological study, particularly in tropical regions known for their rich biodiversity. Among the flora of North Sumatra, *J. altifrons* emerges as a significant species due to its unique adaptations and ecological roles within its habitat. A literature reviews on *J. altifrons* are still very rare until now. Only review articles (not SLR) in the Google Schooler and Scopus database span three decades and reviews of experts or researchers who focus their studies on the relationship between distribution and the others.

2. Methods

The Google Schooler and Scopus database using the phrase "*Johannesteijsmannia altifrons*" and search within "all fields," and the results showed that Google Schooler 158 and Scopus 11 total 169 documents were found. This number is certainly significant and the search is not specific. Therefore, we chose to search within "article, abstract, keywords", which showed results of 149 documents found. To make the search easier and more focused on the analysis, we focused on searching within "article title", where the number of articles found was 34 (article status is 1984–2024). The article with the theme of *Johannesteijsmannia altifrons* presented in the form of a literature review

3. Result and discussion

The species *Johannesteijsmannia altifrons* is deemed vulnerable to extinction because of its restricted range and habitat degradation brought on by land clearing for plantations and other human activities. With a primary distribution in Peninsular Malaysia, Southern Thailand, and portions of Indonesia (including Sumatera), this species is rare and has a restricted range. Due to the ongoing reduction in its natural population, this species has been identified as a plant of conservation concern by the International Union for Conservation of Nature (IUCN) [6,18,19]

Co-occurrence of closely related species can result from secondary contact of taxa that originated allopatrically, which is the evolution of reproductive isolation as a function of geographical isolation, or in the absence of geographical barriers through sympatric speciation, although convincing examples remain few [20]. Palm dispersal processes may play an important influence in determining their geographical distribution. Historical dispersal sections, particularly during the Miocene era, have been proposed to alter palm species diversity in Southeast Asian island biogeography and may shed light on *J. altifrons* current distribution patterns. Furthermore, studies on how Miocene-era events impacted island biota match historical dispersal patterns, implying that similar causes may have influenced this species' current range throughout Southeast Asia [4,9].

This species encounters significant dangers in Sumatra. Forest conversion to Oil Palm Plantations has a negative impact on species diversity in general [21,22]. Therefore, *J. altifrons* populaces tend to be fragmented and are only found in relatively protected areas or those that have not experienced land conversion [16]. The global distribution of *J. altifrons* is impacted by three factors: Physiographic, climatic, and edaphic.

a. Physiographic Factors

Physiographic factors refer to an area's physical conditions (shape and structure), such as elevation, slope, and landforms. The tropical rain forest still creates strong memories about this signature ecosystem, there is a great amount of variety and heterogeneity in the types and extent of tropical forest ecosystems [23]. Of all tropical rainforest regions, Southeast Asia is one of the most geologically dynamic owing to the combination of collision and reorganization of tectonic plates, high levels of volcanic activity and repeated fluctuations in sea level [24,25]. *Johannesteijsmannia altifrons* grows in tropical lowland forests, especially in areas with high mountains or small valleys. Its habitat frequently relates to specific microhabitat characteristics, such as slope position and sunlight intensity. Physiographic investigation reveals that this species' distribution is significantly influenced by slope position, which impacts water drainage and soil moisture. This species prefers habitats in areas with moderate to low direct sunlight because the deep forest canopy protects it from direct sunlight, which is needed for growth [2, 4,6].

Many of *J. altifrons* populations inhabit on hillsides that are higher than 300 meters above sea level (asl) [2]. However, it has been observed at 65 m asl on falling slopes and in freshwater marshes in Johor. It can be found in scrub woodland at 100 metres above sea level in Bako National Park, Sarawak. Palm and

Jochems (1924) The lowest record is in Sumatra, where this palm was discovered growing at 25 m altitude [2], [26]. *Johannesteijsmannia altifrons* is found scattered or as pure stands in the undergrowth in humid primary rain-forest on ridge-tops mostly above 300-500 m [1, 27]. In Ketambe Lowland Forest, *J. altifrons* is found, which is included in Gunung Leuser National Park. This area is an example of a lowland forest ecosystem type, with a general elevation variation [28].

Vegetation has three primary purposes in this regard: shade, evapotranspiration, and wind regulation. The geographic distribution of *J. altifrons* in North Sumatra is significantly influenced by both ecological and evolutionary factors. This palm species thrives predominantly in lowland rainforest areas, where moisture levels and soil composition are optimal for its growth. The diversity and richness of palm species, as examined in various tropical ecosystems, highlight the importance of specific habitat conditions that support these flora [29,30].

Taman Nasional Gunung Leuser (TNGL) represents the lowland to montane tropical ecosystem. TNGL is one of the last remaining areas of natural forest in Sumatra. The region's classification as a national park has allowed for the survival of various rare and indigenous plants, including *J. altifrons*, which was found on sloping soil ≥ 45% and at elevation 20 m-110 m asl [31,32]. In the Bukit Bungkuk Nature Reserve Forest Area covering in Kampar Regency, Riau Province, slope to very steep 41 - 60% and at an altitude between 100 - 500 meters above sea level one of the flora found in this area is *J. altifrons*, which is included in the conserved plants. The landscape of this area is unusual, consisting of lowland rainforest and hills with rich biodiversity [33,34]. Conservation initiatives and ecological research in North Sumatra, knowledge of the environmental elements influencing *J. altifrons* distribution is essential. This palm species has a high preference for particular microhabitats that are influenced by a variety of intricate biogeographic [18,35].

b. Climatic Factors

Microclimatic factors such as light availability, humidity, and temperature changes all have an impact on *J. altifrons* spread. As an understory palm, it flourishes in shaded conditions provided by taller canopy trees, which protect it from direct sunlight while maintaining the high humidity levels required for its growth [6], [23]. The habitat characteristics of *J. altifrons* in Bukit Tigapuluh National Park based on the results of the literature study are known to have a climate that is included in the B climate category. The annual average rainfall is 2,577 mm/year, the highest in October (347 mm) and the lowest in July (83 mm). The soil type in the area is Podsolik with depths varying between 40 cm - 150 cm [36]. *Johannesteijsmannia altifrons* was found in the Ketambe Lowland Forest, which has an average annual rainfall between 2,650-4,700 mm with humidity around 91-96%. [28].

Temperature and humidity levels in the area which is the natural habitat of *J. altifrons* is 24 ° C with a humidity level of 98%. Litter thickness ranges from 1 - 3 cm. Based on field observations, it is known individuals are found growing on hillside areas and not found on hill ridges.[37]. In forest ecosystems, it is known that there are associations that can support life between species to grow together and be able to interact [38]. *Johannesteijsmannia altifrons* is one of the terrestrial long-stemmed litter-eating plants. Leaf blades are borne on long petioles. Leaf litter is funneled by the leaf blade to the center of the plant, where it falls through gaps between the petioles and accumulates in mounds around the short stems [39]. *Johannesteijsmannia altifrons*, thrives in specific climate conditions. Here are the key climate factors for its growth: Temperature: This palm prefers warm, tropical climates. It can tolerate temperatures as low as -4°C but grows best in temperatures above 16°C. Humidity: High humidity is essential for its growth. It does not fare well in low humidity environments. Light: It requires a slightly shaded to semi-shaded environment. Direct sunlight can damage its large leaves. These factors contribute to the optimal growth and health of *Johannesteijsmannia altifrons* in its natural habitat and cultivated environments [13,18,40].

This species primarily inhabits moist, lowland regions with riverbanks and wetlands, where humidity is constantly high and there is a lot of sunlight and shade. Such habitats offer organic matter in addition to enough moisture, both of which are necessary for the development of this rare palm species [39]. It is never found in secondary regrowth forests, and it rarely survives any clear-felling of trees, but often sustains considerable damage from falling trees and scorching when exposed to direct sunlight [2].

Conservation measures were implemented. In Malaysia, it can be found in Taman Negara National Park (Malaya) and Bako National Park (Sarawak). In Indonesia, it is found in the Langkat Nature Reserve (Sumatra), while only in the area that was intensively logged in 1971 [1,2]. *Johannesteijsmannia altifrons* can only be found in two places in Indonesia, namely in Bukit Tigapuluh National Park and Gunung Leuser National Park [32]. Climate factors may serve as a proximate cue for flowering in palms. In the Neotropics, there are numerous studies on the flowering of palms in response to climate factors, which mostly relate to rainfall and very few to both rainfall and temperature [41].

c. Edaphic Factors

Edaphic factors that affect the distribution *J. altifrons* on earth include soil nutrients, soil drainage, soil chemical content, and so on. These conditions affect the optimization *J. altifrons* growth. For example, lowland forest environments with high levels of water and a lot of sandy loam are ideal for *J. altifrons* to develop and spread. It grows well in soils with a pH ranging from 5.5 to 7.5 [2,16]. The breeding system of these species is facultative selfing, which allows reproduction in the absence of pollinators or in isolation [16,18,35].

J. altifron found in Bukit Tigapuluh National Park and Gunung Leuser National Park is distributed at on well-drained, humus-rich and podsolized soils [17]. A vegetation is formed by the presence and interaction of several plant species in it. One form of interaction between these types is association [38].

All *Johannesteijsmannia* species are understorey palms and are obligate shade plants. They cannot survive if the forest canopy is removed, owing to deforestation, leading to the loss of entire populations. If they are of unique genetic make up loss of such populations would be a tremendous blow to the conservation of the species. [9]. However, in light of the numerous medicinal plants and Indonesia's size in general, there is a big gap in their plants conservation [7].

The leaves of *Johannesteijsmannia* also make excellent thatching materials because they are very broad, strong, durable, easy to arrange and waterproof. In Peninsular Malaysia, aborigine villagers in Endau-Rompin State Park, Johor and Sungai Lalang, Hulu Langat, Selangor have been reported to build their houses with the leaves of *J. altifrons*. In the states of Johor and Pahang, Peninsular Malaysia, the leaves of *J. altifrons* are also used to thatch Chinese logging huts and wind-shelters for expedition camping [2,9]. A vegetation is generated by the presence and interaction of multiple plant species. Association is one type of interspecies contact. An association is a different community type that occurs under similar conditions and is reproduced in multiple areas. Associations are distinguished by the existence of similar floristic compositions, homogeneous physiognomy, and a specific environment [42,43], thrives in specific soil conditions promoting growth and health. 1) It prefers well-drained soils to avoid waterlogging, which could damage the roots. 2) The soil should be high in organic matter to supply essential minerals to the plant. 3) It grows in soils with a slightly acidic to neutral pH. Although it can't tolerate drought conditions, the plant needs [1,2, 9, 32].

4. Conclusion

Johannesteijsmannia altifrons is significantly impacted by various environmental three factors: Physiographic, climatic, and edaphic. Understanding these factors is very important for conservation efforts. The findings on the distribution of J. altifrons in North Sumatra provide vital information for the conservation and sustainability of this rare species. This study emphasizes the urgent need for targeted conservation initiatives, especially in the face of biodiversity loss exacerbated by causes like as deforestation and climate change. Finally, understanding the consequences of its distribution pattern is critical for promoting sustainable management techniques that assure J. altifrons survival in the face of growing anthropogenic pressure.

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