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The Expedition of Franz Wilhelm Junghuhn and the Development of Cinchona as a Commodity in the Dutch East Indies (1835–1896)

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Abstract
This article examines Franz Wilhelm Junghuhn's important contribution to the development of cinchona cultivation in the Dutch East Indies, now Indonesia. Junghuhn's extensive expeditions in Java and Sumatra supported the successful adaptation and cultivation of cinchona, an important antimalarial plant, in the region. This article highlights his innovative methods and analyzes the economic, social, and political impacts of cinchona cultivation on the Dutch East Indies government and local communities. It concludes that Junghuhn's work not only advanced botanical knowledge but also played a significant role in combating malaria and strengthening the colonial economy through cinchona exports.

Keywords
Cinchona; Quinine; Dutch East Indies; Junghuhn; Malaria

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Introduction

This study originated from the urgent need of the Dutch East Indies government in the nineteenth century to confront malaria outbreaks that disrupted the social, economic, and political order. Malaria, which spread widely through the bites of Anopheles mosquitoes, posed a serious threat to the health of local communities as well as colonial officials. Cinchona, which contains the alkaloid quinine and functions as an antimalarial medicine, therefore became a solution that was intensively studied. However, the development of this plant faced major challenges because its natural habitat was limited to the Andes Mountains. This study aims to understand the contribution of Franz Wilhelm Junghuhn, a German botanist, to the cultivation of cinchona in the Dutch East Indies. Junghuhn played an important role in developing adaptive cultivation techniques based on his research on the geographical conditions of West Java, which resembled cinchona's original habitat. This study also examines the historical impact of cinchona cultivation on the local economy, public health, and the political position of the Dutch East Indies. Its theoretical foundation draws on previous studies concerning the influence of cinchona in the history of global health, including the role of quinine alkaloids in the treatment of malaria. From an agrarian perspective, the successful development of cinchona shows how scientific approaches could support the strategic and innovative management of natural resources. Through an in-depth analysis of Junghuhn's scientific expeditions, this study offers a new perspective on human interaction with nature in a colonial context. The findings are expected to provide both practical and academic benefits, including serving as a reference for the development of modern agrarian systems that are more adaptive to environmental and health challenges. This study is also expected to contribute to documenting the role of scientists in the botanical and agrarian history of Indonesia.

Method

This study employs the literature review method to analyze Franz Wilhelm Junghuhn's contribution to botanical expeditions and the development of cinchona in the Dutch East Indies during the period 1835–1896. A literature review was chosen because it allows the researcher to collect and analyze secondary data from a range of relevant and credible written sources.

The data sources used in this study include credible books discussing Franz Wilhelm Junghuhn's biography, scientific expeditions in the Dutch East Indies, and the development of cinchona; scholarly journals examining the botanical, medical, and economic aspects of cinchona as well as the contributions of European scientists in the Dutch East Indies; historical documents such as official records, expedition reports, and Dutch colonial government documents related to cinchona policy and management; as well as academic articles and reliable online sources that provide additional supporting information on the research topic.

Results and Discussion

Franz Wilhelm Junghuhn's Expeditions in Java and Sumatra

Franz Wilhelm Junghuhn began his explorations in Java and Sumatra out of a deep interest in the natural world of the Dutch East Indies. This interest was influenced by the remarkable work of Alexander von Humboldt, whose scientific research and topographical mapping of the world inspired many scholars of his time. With a background in therapeutic education in Germany, Junghuhn initially directed his attention to botany, where he studied various kinds of plants. Amid his medical training, he then developed a strong interest in plant science, which subsequently led him to pursue topography, including research on the structure and composition of the earth and the wonders of volcanoes in the Dutch East Indies.

In 1835, Franz Wilhelm Junghuhn arrived in Batavia, the administrative and commercial center of the Dutch East Indies, now known as Jakarta. From this city, he began a series of focused scientific investigations in various regions of the archipelago. In Java, Junghuhn explored mountain slopes and highlands, including the Priangan region and Mount Gede. His research was not limited to plants but also included topographical studies, especially

observations of volcanoes and other landforms. He collected extensive botanical data and documented the various plant species found in these mountainous areas.

Franz Wilhelm Junghuhn began his expedition in Java with the aim of studying the island's natural environment in depth. His primary attention was directed toward volcanology. His early research was conducted in the Dieng Mountains by observing volcanic activity such as craters, hot gases, and geothermal springs. In Java, seine Gestalt, Pflanzendecke und Innere Bauart, Junghuhn recorded and documented the volcanic activity that shaped the landscape of the Dieng region. At Mount Merapi, he studied lava flows and the effects of eruptions on the surrounding ecosystem. His research then continued at Mount Slamet, where he documented volcanic rock formations and the characteristics of eruptive events. Junghuhn also studied Mount Tangkuban Prahu in Bandung, focusing on ancient volcanic activity believed to have formed the Bandung highland basin. In addition, he conducted research in the southern part of Java, such as Kebumen and Gunung Kidul, where he discovered a number of marine fossils in limestone formations. These findings led to the early conclusion that southern Java had once been a seabed. In Banyumas and Nusa Kambangan, Junghuhn examined sedimentary rock structures as well as river flows that formed valleys. Meanwhile, in the Kendeng Mountains, which cover eastern Semarang, Salatiga, northern Sragen, and southern Blora, he documented complex rock layers consisting of both sedimentary and volcanic elements. His research later continued in the Priangan region, such as Garut and Tasikmalaya, to examine the volcanic activity of Mount Guntur and Papandayan, with a focus on landscape changes caused by eruptions. In his investigations, Junghuhn employed geological methods in the form of rock-layer analysis, erosion studies, and direct observations of cliffs, valleys, and natural exposures. This systematic approach made his exploration of Java one of the most comprehensive studies of geology and volcanology of its time (Junghuhn, 1857).

During his expeditions, Franz Wilhelm Junghuhn not only focused on volcanology and geology, but also examined vegetation, flora, topography, landscapes, and paleontological data on the island of Java through a structured, comprehensive, and innovative approach. In his notes, Junghuhn connected geological characteristics with the kinds of plants that could grow in different regions, thereby producing a holistic understanding of the interaction among soil, climate, and vegetation in shaping ecosystem complexity. He studied vegetation across a range of ecosystems, especially tropical rainforests and grasslands dominated by alang-alang. Junghuhn noted that the diversity of soil types, such as volcanic and sedimentary soils, influenced the growth and development of certain plants, including shallow-rooted species such as alang-alang. He also emphasized the importance of elevation in categorizing types of flora, because lowland vegetation differs greatly from highland vegetation, such as that found in the Dieng Mountains. Through a geological approach, Junghuhn analyzed landscape topography to understand how physical forms such as valleys, plateaus, and mountains were shaped by erosion, sedimentation, and volcanism. He documented that volcanic activity not only altered topography but also created fertile ecosystems that supported high biodiversity. In southern Java, he also examined karst topography in the form of caves, basins, and distinctive valleys that served as habitats for particular flora. In coastal areas, Junghuhn's notes show how coastal abrasion also helped shape diverse coastal ecosystems. In addition, Junghuhn paid attention to paleontology on the basis of fossil discoveries in rock layers, especially sedimentary and limestone formations. He documented marine animal fossils such as mollusks and corals, leading him to conclude that much of Java had once been submerged and may have formed part of the ocean floor. By using these fossil data, Junghuhn estimated the geological age of rock formations as well as patterns of environmental change that had occurred in Java in the past (Junghuhn, 1857). Junghuhn's discoveries of plant fossils were relatively limited, but they still provided information about the evolution of terrestrial ecosystems in Java. Fossils found in coal and sedimentary layers suggest that Java once possessed rich ancient forests during the Tertiary era.

Franz Wilhelm Junghuhn arrived in Sumatra to study the island's topography through a scientific approach that combined geography, geology, astronomy, and botany. In mapping

Sumatra, Junghuhn used cartographic techniques based on astronomical measurements. Geographical positions, both latitude and longitude, were measured with instruments such as theodolites and sextants to ensure mapping accuracy. In addition, he used trigonometry to map the distances and elevations of mountains, valleys, and other areas. This approach enabled Junghuhn to produce detailed maps of Sumatra, including the Batak region and other areas that had previously been poorly documented. He also conducted geological research to understand the formation and physical structure of Sumatra by paying attention to rock types, soil layers, and volcanic activity that shaped the island. In addition, Junghuhn examined volcanic craters, large lakes, and rivers formed by volcanic activity. His emphasis on volcanism as the principal factor shaping Sumatra's topography reflects a geological understanding that was modern for its time (Junghuhn, 1847).

In his notes, Franz Wilhelm Junghuhn began his study by describing the general geography of Sumatra, including its landforms, soil structure, and mountain configurations, all of which formed important parts of the island's overall structure. According to Junghuhn, Sumatra's landscape from south to north was dominated by a chain of volcanic mountains stretching along the western coast. These mountains were regarded as one of the key systems regulating the island's hydrology while also serving as a geographical barrier separating lowlands from highlands. Junghuhn also noted that the mountains of Sumatra were divided into several parallel ranges separated by elongated valleys. These valleys often became centers of human life because their fertile environments supported agriculture, especially rice cultivation. He further recorded that the mountains of Sumatra varied in elevation, with Mount Kerinci identified as one of the highest peaks. In his research, Junghuhn explained that many mountainous regions in Sumatra were extremely steep and rugged, making them difficult to access and thus obstructing more detailed mapping. He also emphasized the importance of rivers flowing from the mountains to the lowlands. Rivers such as the Batang Hari and Musi were considered vital as transportation and trade routes while also creating diverse ecosystems along their valleys. In addition, Junghuhn observed that Sumatra's western coast was relatively narrow because the mountains nearly touched the sea, whereas the eastern part was dominated by much broader plains. According to Junghuhn, Sumatra's geological conditions were strongly influenced by volcanic activity, as shown by the many craters and remnants of volcanic eruptions that shaped the island's distinctive character (Junghuhn, 1847).

Franz Wilhelm Junghuhn also documented the topography and geology of the Batak region and provided a fairly in-depth description of the Batak people, their lives, and his direct interactions with them during his expedition. Junghuhn divided the Batak region into several provincial sections with detailed maps and descriptions. He recorded the existence of extensive highlands, especially around Lake Toba, which is geographically surrounded by steep mountains. Junghuhn described the topography of the Lake Toba area as a region composed of fertile valleys, towering hills, and volcanic highlands with distinctive characteristics. Large and small rivers in the Batak region, such as the Asahan and Silindung, became a focus of his research because they played an important role in the lives of local communities and in trade routes. During his research in the Batak region, Junghuhn also interacted directly with the Batak people. He studied their way of life, social system, and local culture. One of his research concerns was to correct the negative stigma of cannibalism that was often attached to the Batak people. According to Junghuhn, earlier reports by explorers and missionaries concerning Batak cannibalism tended to be exaggerated. He emphasized that the Batak were a well-organized community, rich in customs and skilled in arts and crafts (Junghuhn, 1847).

In Franz Wilhelm Junghuhn's notes, the social structure of Batak society appears quite complex, with the marga, or clan system, playing an important role in their lives. In addition, Junghuhn observed forms of local government based on deliberation, indicating that Batak society had developed structured mechanisms of decision-making at the local level. He also documented Batak traditions, clothing, vernacular architecture, and farming practices. Junghuhn described Batak traditional houses as stilt houses filled with distinctive carvings. He also recorded patterns of Batak migration from the highlands to the lowlands. His research provides

an image of the harmony between Batak society and its surrounding environment. Junghuhn's studies reveal his respect for and appreciation of Batak culture, while also emphasizing that Batak society possessed the potential for cultural and intellectual development. Through research conducted in a scientific and humane manner, Junghuhn presented a new perspective on the Batak people to the outside world, which had previously described them negatively through prejudice and inaccurate reports. Junghuhn's research in Sumatra became one of the important documentations of the Batak region and its people in the nineteenth century (Junghuhn, 1847).

Junghuhn's efforts in Java and Sumatra constituted a systematic attempt to gather information that could be used to produce accurate topographical maps, which later became an important foundation for further scientific research. In addition, his geographical and ethnographic documentation made a significant contribution to scientific understanding of nature and culture in the Dutch East Indies at the time. The results of his research were disseminated through various diaries and books, which not only enriched scientific knowledge but also influenced Dutch colonial economic development and colonial order.

The Development of Cinchona and Its Influence on the Dutch East Indies

Cinchona, also known as Peruvian bark, is a type of plant that grows extensively in the Andes Mountains of South America. It belongs to the Rubiaceae family and can grow either as a large shrub or a small tree. Cinchona became an important commodity because it contains quinine alkaloids known as powerful antimalarial agents. The alkaloids found in cinchona include quinidine, cinchonine, and cinchonidine (Gurung & De, 2017).

In the seventeenth century, cinchona became highly sought after when malaria outbreaks spread and became a serious problem, especially in Europe and tropical regions. Malaria is a disease caused by Plasmodium parasites and transmitted through the bites of Anopheles mosquitoes. The disease created severe disruption because of the high mortality and suffering it caused. At that time, no truly effective cure for malaria had yet been discovered, until cinchona was recognized as capable of treating it. However, a major obstacle emerged because cinchona could not grow just anywhere; it thrived only in particular regions, especially its original habitat in the Andes Mountains. In the early nineteenth century, scientists increasingly realized the importance of cultivating cinchona outside its native region because of its urgency for public health. One of the scientists who sought to realize this effort was Sir Clements Markham, an English botanist and explorer. Markham's efforts began in the 1850s by transferring cinchona seedlings from South America to European colonies in Asia and Africa. Markham realized that malaria could only be addressed effectively if cinchona were planted in environments with suitable conditions, especially tropical regions (Windi, 2024).

In the Dutch East Indies, efforts to cultivate cinchona had been underway since 1829. Dr. Carel Lodewijk Blume, as director of the Bogor Botanical Gardens, had once attempted to plant cinchona on vacant government-provided land, but the effort failed. In 1851, the Leiden Nursery succeeded in cultivating Calisaya cinchona seedlings, which were then sent to Java for further propagation. In Java, specifically at the Bogor Botanical Gardens, the development of cinchona under the leadership of Dr. Teijsmann again produced unsatisfactory results. The Dutch East Indies government, which recognized the importance and potential of cinchona, then obtained support from Governor-General Ch. F. Pahud. Pahud subsequently ordered cinchona trees to be transferred from South America to Java. He summoned Junghuhn, who was known as a naturalist, to assist in the development of cinchona in Java. Together with his team, Junghuhn began a series of experiments to find the best way to plant and care for cinchona so that it could grow outside its native habitat and adapt to the tropical climate of the Dutch East Indies. After several years of carrying out this task, Junghuhn fell ill and ultimately handed the work over to one of his team members, the botanist J. K. Hasskarl, who had long been in the Dutch East Indies (Gorkom, 1889).

Hasskarl then continued Junghuhn's task and planned a journey to South America to obtain cinchona directly. This assignment became extremely difficult when Hasskarl realized that the Indigenous communities inhabiting the region held cinchona in very high regard, so its location

was kept secret. With assistance from the Dutch East Indies government, Hasskarl undertook his departure in strict secrecy. The difficulties increased when information leaked in The Hague and was subsequently reported in German newspapers (Moens, 1882). Hasskarl, who decided to use the alias Dr. Carl Muller, ultimately succeeded in deceiving both government authorities and the press and arrived in Peru.

After a long process of dealing with the Peruvian government administration, interacting with Indigenous communities, and locating the plant, Hasskarl succeeded in packing about 21 wooden crates that were intended to be sent to the Netherlands for cultivation in Leiden (Vriese, 1857). However, the British learned of Hasskarl's disguise and attempted to acquire large quantities of cinchona. While in Islay, Scotland, Hasskarl even received the highest offer from the British. He nevertheless sold some of the cinchona seedlings to Britain, then immediately returned to Peru and sent a letter to the Dutch government requesting that the cinchona seedlings be collected directly in Peru and transported via the Pacific route to the Dutch East Indies. In August 1854, Hasskarl successfully returned to the Dutch East Indies carrying hundreds of cinchona seedlings aboard the SS Prins Frederik Hendrik (Kunto, 1986).

In 1856, Hasskarl decided to pause his work after completing his mission in South America and returned to Europe to rest. Pahud then called Junghuhn back to continue the task after his condition had improved. Junghuhn was deeply trusted by Pahud because of his exceptional dedication and his mastery of the natural environment of Java, which he had studied during his expeditions, so he was regarded as the person who knew Java most thoroughly at the time (Vriese, 1857). While in Java, Junghuhn simultaneously served as head of the cinchona plantation and head of scientific research with strong support from the Governor-General of the Dutch East Indies. He even received approximately 4,400 guilders for equipment and research books. After Hasskarl's departure, only about 167 cinchona trees remained, 96 of which were of the Ovata variety known as Pahudiana cinchona (Nijhoff, 1910). Junghuhn realized that the soil in Cibodas was too thin in structure, so he decided to move cinchona cultivation to Pangalengan in Bukit Malawar. According to Junghuhn, cinchona should be planted in a more natural location resembling its habitat in South America, namely deep forest areas.

Franz Wilhelm Junghuhn was regarded as a brilliant scientist because cinchona cultivation was an extremely difficult undertaking that required environmental conditions as similar as possible to those of the Andes Mountains, both in terms of soil and climate. From among the various regions of the Dutch East Indies, Junghuhn chose the Pangalengan hills as the site for cinchona propagation, a decision that grew out of his experience researching the topography and geography of Java. Junghuhn's idea was widely appreciated because, amid competition among colonial states that were likewise attempting to cultivate cinchona but often failed, he instead succeeded in producing thousands and even millions of mature cinchona plants in the Dutch East Indies. Nevertheless, toward the end of his life Junghuhn received harsh criticism. This occurred because he was considered to have grown arrogant as a result of his success and had begun to reject criticism from various scientists and chemists, such as K. W. Van Gorkom, J. E. de Vrij, and H. A. Wedell. In managing cinchona, Junghuhn was also considered to have ignored Hasskarl's knowledge concerning the care of cinchona in Peru. Junghuhn focused on propagating the Pahudiana variety, which could produce more seeds than the Calisaya variety, although Calisaya contained higher levels of quinine alkaloids. Junghuhn died in 1864 after being removed from his position by the new Governor-General of the Dutch East Indies, General Sloet van de Beele, and the management of the cinchona plantation was then handed over to K. W. Van Gorkom (Goss, 2014).

Van Gorkom continued the development of cinchona by learning from Junghuhn's earlier mistakes, especially his tendency not to distinguish among the qualities of cinchona seeds. Gorkom considered that Junghuhn had focused too heavily on a single variety, namely Pahudiana, and prioritized quantity over quality. By contrast, Gorkom planted various kinds of seeds in order to identify cinchona with the highest quinine content and the best quality. At that time, the Dutch East Indies was unable to compete with the British market because the abundant production of Pahudiana cinchona could not rival the Calisaya cinchona cultivated by the

British, which had a higher quinine content. Meanwhile, Charles and George Ledger developed cinchona seeds whose quinine content even exceeded that of Calisaya. These seeds were once offered to the British government, but they were rejected for certain reasons and out of concern that they would disrupt the existing cinchona market. Because cinchona seeds could not last long, George then offered them to the Dutch government, which purchased one pound of cinchona seeds for 100 guilders. Gorkom and his colleague Moens began planting these seeds in 1866. After five years, the plants produced cinchona with a very high quinine content that later became known as the Ledgeriana variety. Although Gorkom's research yielded fairly satisfying results, he still received sharp criticism from officials and scientists in both the Dutch East Indies and the Netherlands concerning the limited profits made during his leadership of the cinchona plantations. Seeing this great potential, the Dutch East Indies government then issued Decision No. 67 dated 12 November 1867, ordering cinchona plantations to distribute seeds to local communities, especially in Banyumas, Pekalongan, Cirebon, Bogor, and Tegal, so that cinchona cultivation could expand across Java (Windi, 2024).

The Ledgeriana variety successfully cultivated by Gorkom could reach a peak market price of around 9.3 guilders per kilogram, or four times the selling price of the Calisaya variety. The Dutch East Indies government obtained enormous returns after approximately twenty years of research to develop cinchona on Java, eventually making the colony one of the world's largest cinchona producers, with profits of 48,846 guilders or the equivalent of Rp 434,618,894.18 (rupiah value as of 3 December 2024) (Merdeka.com, 2021). As the Dutch East Indies government became increasingly serious about the market gains from cinchona sales, it was encouraged to establish a special cinchona-processing factory called the Bandoengsche Kininefabriek (BKF) in 1896. With the establishment of this factory, the Dutch East Indies government could process medicines independently and earn greater profits. Previously, the colonial government had depended on the German cinchona industry, which heavily monopolized global prices for quinine-based medicines, making BKF an important solution for the colonial administration (Roersch van der Hoogte, 2015). For cinchona plantation entrepreneurs in Java, BKF became an important support because its presence helped reduce the pressure caused by selling cinchona to Europe at low prices. In this way, continuity was created between BKF and cinchona entrepreneurs in Java because both benefited from the arrangement. The Dutch East Indies government gained not only a new raw commodity but also semi-processed products such as quinine sulfate, as well as BKF research outputs in the form of sugar-coated quinine tablets distributed at around 160 kilograms per day (Luthfi & Wahid, 2019).

Conclusion

Franz Wilhelm Junghuhn, a German botanist, played an important role in the history of cinchona development in the nineteenth-century Dutch East Indies (Amt, n.d.; Junghuhn, 1847). As a researcher with a profound love of nature, Junghuhn investigated not only flora and fauna, but also geographical and volcanological phenomena in various parts of Java and Sumatra. His works offered new insights into the ecosystems, topography, and biodiversity of both islands. One of Junghuhn's greatest contributions in the Dutch East Indies was his effort to cultivate cinchona in Java. At that time, the Dutch East Indies government faced the serious threat of malaria. Cinchona was introduced as a solution to this problem because its quinine alkaloid content was effective against malaria, even though the plant was native to the Andes Mountains of South America. The need to adapt cinchona to a new environment posed a major challenge for Junghuhn in his attempt to propagate the plant in Java (Windi, 2024). Cinchona was initially planted at the Bogor Botanical Gardens, but Junghuhn later moved it to Pangalengan because he considered the area more ideal and more similar to cinchona's original habitat. Junghuhn's years of work produced millions of cinchona plants capable of surviving and adapting to the Javanese environment. Although he faced various criticisms near the end of his life, Junghuhn remains remembered as a pioneer of cinchona cultivation in the Dutch East Indies. After Junghuhn's

death, the development of cinchona was continued by Van Gorkom, who concentrated on high-quality cinchona, namely C. ledgeriana. The development of the Ledgeriana variety subsequently stimulated the economy of the Dutch East Indies government until the colony became known as one of the world's largest cinchona producers. The Dutch East Indies government also established the Bandoengsche Kininefabriek in 1896 as an important step in the industrialization of cinchona in the Dutch East Indies. The factory was built to process cinchona into finished products, reduce dependence on Germany, and increase export profits.

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