

# A Taxonomy Review of *Zingiber* Mill. (Zingiberaceae) in Peninsular Malaysia

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## Abstract

Herbaceous plants of the *Zingiber* Mill. are widely distributed throughout Peninsular Malaysia. A total of 25 species comprising approximately 30 taxa have been discovered in Peninsular Malaysia. Acceptance of the current classification is predominately based on morphological characteristics. Furthermore, additional details like the presence of an aromatic fragrance aid in distinguishing between related species. Nonetheless, significant fieldwork and evolutionary analysis aid in the taxonomy of *Zingiber* in Peninsular Malaysia. This review aims to give a broad overview of the identification and classification of the genus *Zingiber* in Peninsular Malaysia that has been documented in the literature previously.

## 1. Introduction

The Zingiberaceae family, also called the ginger family, comprises more than 1,300 species and 52 genera. *Zingiber* Mill. (true ginger), *Hedychium* Koenig, *Curcuma* L. (turmeric), and *Alpinia* Roxb are the examples of well-known genera in Zingiberaceae. Rhizomes in this family typically develop underground and are rhizomatous. Consistently simple, the leaves are arranged in a dichotomous plane (two ranks) and frequently in parallel venation. The Zingiberaceae family's pseudostem, or false stem, comprises an overlapping sheath. An exceptional characteristic is that the inflorescence emerges apically at the foliage branches or basally from the rhizome. Additionally, the flowers are bisexual and zygomorphic (having a symmetrical shape along one plane only) and epigynous (having the ovary situated above the points of attachment of the other floral parts). Zingiberaceae fruits are, intriguingly, diverse. They can be fleshy, dry, dehiscent (splitting open to release seed once it matures), or dehiscent (not splitting open). The fruits are often capsules [1] In addition, numerous Zingiberaceae plants are utilized extensively as condiments for medications and flavorings in the culinary, with immense economic and cultural significance [2]. Also, Zingiberaceae plants are sometimes exploited as ornamental plants as the beautiful flowers and foliage are cultivated [1], [3]. Additionally, they are employed in various religious and cultural rites across the globe. Certain varieties of these aromatic perennials can thrive in direct sunlight, while others prefer shady, moist areas near stream banks or decaying bark and rocks. Interestingly, most Zingiberaceae species bloom frequently and thrive year-round [4], [5], [6]. While the majority of wild gingers are found in terrestrial environments, there are a few exceptional native species that grow as epiphytes. These include *Hedychium longicornutum* Griff. ex-Baker and *Epimomum roseisquamosum* (Nagam. & S. Sakai) A.D. Poulsen & Škorničk, which clings to the branches of trees and palms [6].

Genus *Zingiber*, a genus named after the Sanskrit term "*Singabera*," is distinguished by its notable attributes, most notably the pulvinus, which functions as a crucial distinguishing feature even in the absence of fruits and flowers. *Zingiber* plants are further distinguished by their horn-shaped anther crest and joined lateral staminodes [7]. The crucial researchers for *Zingiber* in Peninsular Malaysia are as follows: Schumann, Valetton,

Ridley, Holttum, Theilade, Lim and Meekiong [3], [8], [9], [10], [11], [12], [13], [14], [15]. Genus *Zingiber*, specifically in Peninsular Malaysia, is known for its complex taxonomy with numerous closely related species that can be difficult to distinguish. This complexity poses challenges for classification and identification. Some species might have been overlooked in previous studies, leading to confusion in the classification. Currently, 25 wild *Zingiber* species with 30 taxa have been acknowledged in Peninsular Malaysia (Table 1).

**Table 1** *Zingiber* species of Peninsular Malaysia

Species name and authorship	
1. <i>Z. aurantiacum</i> (Holttum) Theilade	16. <i>Z. longibractetaum</i> Theilade
2. <i>Z. angustifolium</i> C.K.Lim and Meekiong	17. <i>Z. malaysianum</i> C.K.Lim
3. <i>Z. belumense</i> C.K.Lim and Meekiong	18. <i>Z. multibracteatum</i> var. <i>multibracteatum</i> Holttum
4. <i>Z. chrysostachys</i> Ridl.	19. <i>Z. multibracteatum</i> var. <i>viride</i> Holttum
5. <i>Z. curtisii</i> Holtt.	20. <i>Z. nazrinii</i> C.K.Lim and Meekiong
6. <i>Z. elatius</i> (Ridl.) Theilade	21. <i>Z. petiolatum</i> (Holttum) Theilade
7. <i>Z. flaviflorum</i> C.K.Lim and Meekiong	22. <i>Z. puberulum</i> var. <i>chryseum</i> (Ridl.) Holttum
8. <i>Z. fraseri</i> var. <i>fraseri</i> Theilade	23. <i>Z. puberulum</i> var. <i>puberulum</i> Holttum
9. <i>Z. fraseri</i> var. <i>major</i> (Ridl.) Govaerts	24. <i>Z. raja</i> C.K.Lim and Kharukanant
10. <i>Z. fraseri</i> var. <i>nervifolium</i> (Meekiong and C.K.Lim) Govaerts	25. <i>Z. sabun</i> C.K. Lim
11. <i>Z. gracile</i> Jack	26. <i>Z. sulphureum</i> Burkill ex Theilade
12. <i>Z. griffithii</i> Baker	27. <i>Z. spectabile</i> Griffith
13. <i>Z. kelantanense</i> C.K. Lim	28. <i>Z. wrayi</i> var. <i>halabala</i> C.K.Lim
14. <i>Z. kunstleri</i> King ex Ridl.	29. <i>Z. wrayi</i> var. <i>wrayi</i> (Prain ex Ridl.) Ridl
15. <i>Z. limianum</i> Meekiong	30. <i>Z. zerumbet</i> (L.) Roscoe ex. Sm.

## 1.1 Classification of *Zingiber* in Peninsular Malaysia

Earlier studies of Zingiberaceae highlight the challenges early botanists face in studying and preserving fragile plant specimens, especially concerning the delicate nature of *Zingiber* flowers. This difficulty in preservation likely posed obstacles to the accurate identification and classification of specific *Zingiber* species [4], [8], [9], [10].

Following this, Holttum identified *Z. gracile* Jack, *Z. griffithii* Baker, and *Z. puberulum* Ridl as the three complex species found in Peninsular Malaysia. The presence of those species in *Zingiber* of Peninsular Malaysia sparked uncertainty [4]. Holttum described three variants of *Z. gracile*, namely *Z. gracile* var. *aurantiacum* Holttum, *Z. gracile* var. *elatior* Ridl., and *Z. gracile* var. *petiolatum* Holttum, all of which he stated "may later rank as distinct species." However, the specimens are considered improbable because of their similarity to *Z. griffithii* [4]. Nevertheless, the variations were then later upgraded to species classification by Theilade [5]. She stated, "Ridley classified *Z. elatior* as a species." Ridley did not, however, publish *Z. elatior* at any ranking [10], [16], [17]. An improper epithet was applied to *Z. elatior*, and Theilade does not author the rank modifications. Turner and Leong-Škorničková suggested that the accurate authorship of *Z. elatior* is *Z. elatius* (Ridl.) Theilade [17], [18]. A thorough examination was conducted on the specimens from SING and K and determined the new lectotypification of *Z. elatius* Ridley 9340 (lectotype K! [barcode K000255246]), as this is the only specimen from Penang Hill that fits the original description (at least in several parts) [17].

The complex species *Z. elatius* resembles *Z. purpureum* (cultivated species that are rare in Malaysia) vegetatively with its linear leaves than other related species, such as *Z. aurantiacum* (Holttum) Theilade, *Z. petiolatum* (Holttum) Theilade, and *Z. gracile*, which have lanceolate leaves. These characteristics are essential for classifying the plants into specific species. However, *Z. petiolatum*, *Z. aurantiacum*, and *Z. elatius* may share similarities concerning their slender inflorescences. Lim stated, "*Z. gracile* var. *elatior* may be included in *Z. griffithii* and *Z. gracile* complex to maintain its variety status" [13]. After closely examining Theilade's description in her account, *Z. elatius*, *Z. aurantiacum*, and *Z. griffithii* appear to feature intermediate morphological traits for the vegetative and floral structure, except for the leaves' shape and the lack of sufficient information regarding *Z. elatius*' capsules. *Zingiber griffithii* bears pink-turning red bracts, whereas the orange-to-red bracts (when ripe) of *Z. elatius* and *Z. aurantiacum* coincide with *Z. gracile*. However, the bracts' coloration could be regarded as a variation. Furthermore, compared to *Z. gracile*, the two species, *Z. elatius* and *Z. aurantiacum*, are larger plants with shorter ligules [5]. In contrast to Theilade's description, Lim [13] found that *Z. elatius* is relatively tiny as observed at the type location (Penang Hill); however, Theilade never went into detail about the distinctive feature of *Z. elatius* flowers, which are tiny red and black lines on the lips as reported

solely by Burkill, S.F.N. 3312 – the specimen is unknown until now [4]. To date, *Z. elatius* has yet to be further discussed as no fresh collections have been made and remain as the specific rank.

Although *Z. gracile* is not typically small, Lim and Meekiong [14] confirmed that some specimens obtained at the type locality (Penang), where the species is thought to be hyperendemic, reach 3.5 meters in height. Compared to larger *Zingiber* plants, such as *Z. spectabile* Griff. in Peninsular Malaysia, the inflorescence and available seeds are far more gigantic. However, herbarium specimens labeled with *Z. gracile* would be erroneous if not collected from Penang and lacked that distinctive characteristic of the thin scarious ligule [14]. Revisions to herbarium specimens and samplings in the type locality that concentrate on critical morphological features such as the ligule, labellum coloration, and inflorescence may help identify the species correctly.

Even though the name *Z. petiolatum* was given due to the presence of longer petioles, it appears to be misleading because many specimens found in the herbarium have nearly sessile petioles, measuring between 5 and 15 mm, as described by Holttum [4]. Lim [13] stated that the longer petiole might be from a different taxon (*Z. longibracteatum* Theilade; Kiew, RK 5151). *Zingiber petiolatum* lacks a detectable scent, unlike *Z. aurantiacum*, which has a strong aromatic scent. Furthermore, it was previously mistakenly believed that *Z. petiolatum* was part of the Larsen 42986 collection from Bacho Falls, Narathiwat. However, the unique purple labellum and orange inflorescence demonstrated that this was a different taxon, leading to the explicit description of a new species by Lim (*Z. raja* C.K. Lim & B. Kharukanant) [13], [19]. According to Lim, *Z. raja* and *Z. kelantanense* are morphologically similar to *Z. petiolatum*. He also said that *Z. kelantanense* "flowers are cream" (like *Z. petiolatum* and *Z. aurantiacum*), but so far, the geographical locations are very dissimilar, as *Z. petiolatum* and *Z. aurantiacum* can be found in higher altitude meanwhile *Z. kelantanense* found primarily in Kelantan, however, given that neither species has any information regarding its fruits. *Zingiber kelantanense*, on the other hand, is distinguished by its leaf shape and ornamentation, which feature prominent veins even though it is said not to have a detectable scent like *Z. petiolatum*. In addition, *Z. raja* is easily recognized in the wild when sterile due to its floppy leaves and purple labellum with cream spots [13].

Another complex species is *Z. puberulum*, which Holttum previously classified into two varieties: *Z. puberulum* var. *chryseum* (Ridl.) Holttum and *Z. puberulum* var. *ovoideum* Holttum (synonym: *Z. fraseri* var. *major* (Ridl.) Govaerts). Even though the original specimens were in Singapore, it is frequently seen in the southern Peninsular of Malaysia. The hairiness of *Z. puberulum*'s ligule, leaf sheaths, and flowering bract is widely known. However, the color of the *Z. puberulum* flower and the bract of the inflorescence are incredibly similar to those of the *Zingiber* in Peninsular Malaysia, which is yellow when young, turns pink with age and has a cream-colored labellum [4]. In contrast to *Z. puberulum* var. *chryseum*, which Ridley initially discovered at Bukit Timah in 1894, this species is nearly glabrous and bears a characteristic yellow flower bract. However, it is still unknown whether the glabrous characters are always related. Due to the land clearance for the development, no additional materials have been collected in Singapore since the initial description of *Z. puberulum* var. *chryseum*. It is thought to have vanished in Singapore due to inadequate documentation and data [17]. According to Holttum [4], Corner had previously collected a plant from Ulu Segun, Gunung Panti, Johor that was similar to this type. He observed that the plant was almost glabrous and slightly hairy. Furthermore, the bract had a yellow tint, although the species (S.F.N. 30658) was not confirmed. Since no new samples were discovered throughout Lim and Meekiong's study, they tended to accept Holttum's description of *Z. puberulum* var. *chryseum* as a variant of *Z. puberulum* [14]. The existence of this variety and whether it was taken when it was young are yet unknown due to the inflorescence's coloration. Additionally, as many specimens from Peninsular Malaysia and Thailand were puberulous, the hairiness trait is not a reliable way to identify the plants. Thus, comprehensive and timely botanical studies are crucial since influences such as habitat changes and land clearance affect the existence and documentation of these species.

Except for a few species, Theilade only made revisions to the *Zingiber* of Peninsular Malaysia using herbarium specimens. As a result, she identified *Z. fraseri* Theilade as a new species, which has the unusual trait of producing long trailing leafy stems [5]. However, her findings conflicted with those of Lim and Meekiong [14], who thought she needed more exposure to the *Zingiber* species in Peninsular Malaysia. Another species exhibiting this habit is *Z. griffithii* var. *major*. For this reason, the authors proposed classifying *Z. fraseri* as a basionym of *Z. griffithii* var. *major* to elevate the rank to species named *Z. besar* C.K. Lim & Meekiong (type: Bujang Melaka, Perak). In addition to delineating the species' habit and its substantial leaves, the epithet *Z. besar* was selected to prevent any potential confusion arising from the synonymies. Furthermore, based on Ridley's sample from Tembeling, Pahang, they thought *Z. puberulum* var. *ovoideum* to be the same species as *Z. griffithii* var. *major*. The reduction of *Z. fraseri*, *Z. puberulum* var. *ovoideum*, and *Z. griffithii* var. *major* to *Z. besar* was thus suggested. The groupings are mainly because of the large plants and large flowers. On the other hand, *Z. besar*'s inflorescences come in various colors, including yellow, orange, and dark pink. Additionally, each specimen from a different location has a unique aroma, which might be pleasant, less fragrant, or more pungent, similar to the scent of local massage oils [14]. After examining those related species, Lim and Meekiong [15] re-established *Z. fraseri* as a variant of *Z. besar*, namely *Z. besar* var. *fraseri*. Additionally, *Z. besar* var. *nervifolium* C.K. Lim & Meekiong was included as a new variety. Goaverts [20] corrected this superfluous term for *Z. fraseri* and their

relationship. The proper names must be recombined under *Z. fraseri* because the varietal name used was older than *Z. besar*. As a result, *Z. fraseri*, *Z. fraseri* var. *major*, and *Z. fraseri* var. *nervifolium* are the three recognized infraspecific names listed in The International Plant Names Index (IPNI) [21].

*Zingiber griffithii* is another problematic species in Peninsular Malaysia, and it is the most prevalent lowland species in Peninsular Malaysia's southern region. However, it is sometimes confused with other species, such as *Z. gracile* and *Z. puberulum*. Despite having characteristics in common with *Z. griffithii*, such as small-size plants, sericeous leaves, erect inflorescences, and white to cream labellum, *Z. citrinum* Ridl. was previously classified as a separate taxon by Holttum and Theilade. However, *Z. citrinum* differs from *Z. griffithii* in terms of leaf size, broader inflorescence, and yellow bract inflorescence. Nonetheless, Holttum [4] has skepticism about whether the large leaves are always associated with the yellow inflorescence bract. For this reason, he classified *Z. citrinum* under *Z. griffithii*. On the other hand, the distinctive feature—subtly ribbed, veined leaves—may help to distinguish the species as a variant [14]. Additionally, the inflorescence bract's hue provides crucial information for classification.

Furthermore, prior identifications of *Z. sulphureum* Burkill ex Theilade this species is confused with two complicated species: *Z. griffithii* and *Z. gracile*. However, the plant is considered the smallest compared to those species. Besides the small size, the characteristic that sets it apart is the ovate leaves and sulphur-yellow inflorescence bract that can easily be distinguished in the field. According to Cowley and Theilade [22], the environment of granite and limestone may cause sulphur-yellow bract flowers.

Therefore, a taxonomic investigation of *Zingiber* in Peninsular Malaysia is essential to comprehend the complexities of the *Zingiber* species. To assure proper identification and classification, thorough assessments of living materials and herbarium specimens for *Zingiber* in Peninsular Malaysia are urgently needed. There is a need for meticulous observation and analysis, especially when dealing with species that share common traits. It is unfathomable how vital it is to examine newly collected *Zingiber* specimens, as they contain an abundance of data indispensable for precise categorization. The coloring, texture, and other subtle characteristics of the live *Zingiber* plant that may not be as obvious in dried herbarium specimens are made possible by fresh specimens.

Furthermore, it is critical to incorporate an analysis of morphological and ecological characteristics and variations within species to reveal the complex *Zingiber* species in Peninsular Malaysia. Clarifying the relationships between closely related species of *Zingiber* in Peninsular Malaysia can also be significantly aided by molecular techniques like DNA analysis. The combination of the leaves, flowers, and aroma could allow for the classification of the species into a new taxon. However, more information about the fruits significantly contributes to accurately identifying and classifying *Zingiber* species in Peninsular Malaysia.

## 2. Conclusion

Considering multiple aspects of botanical research, an integrated approach demonstrates a holistic perspective necessary for a thorough understanding of Peninsular Malaysia's *Zingiber* species. Continued research in these areas will refine the classification of *Zingiber* species and contribute valuable data for conservation efforts, ecological studies, and a broader understanding of the evolution of *Zingiber* species in Peninsular Malaysia.

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## Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper

## Author Contribution

This journal requires that all authors take public responsibility for the content of the work submitted for review. The contributions of all authors must be described in the following manner:

The authors confirm contribution to the paper as follows: **study conception and design:** Aimi Syazana Sedek, Salasiah Mohamad; **analysis and interpretation of results:** Aimi Syazana Sedek, Salasiah Mohamad; **draft manuscript preparation:** Aimi Syazana Sedek, Salasiah Mohamad. All authors reviewed the results and approved the final version of the manuscript.

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