**BIODIVERSITAS**
Volume 23, Number 4, April 2022
Pages: 1734-1744

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d230403

# The diversity and distribution of *Alpinia zerumbet* clade in West Malesia

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Manuscript received: 24 January 2022. Revision accepted: 10 March 2022.

**Abstract.** *Setiawan E, Ardiyani M, Miftahudin, Poulsen AD, Chikmawati T. 2022. The diversity and distribution of* Alpinia Zerumbet *clade in West Malesia. Biodiversitas 23: 1734-1744. Alpinia* belongs to the family Zingiberaceae and tribe Alpinioideae. One of the centres of *Alpinia* diversity is in Malesia, yet information regarding the taxon in this area is very limited. Furthermore, species richness and distribution in West Malesia have not been well documented particularly in respect of the taxonomical development following clade classification. The aim of the current paper is to study the morphological diversity and distribution of *Alpinia Zerumbet* clade in West Malesia to provide taxonomic information. Exploration was done in several locations in Java and Sumatra. Data were obtained from fresh and herbarium specimens preserved in three herbaria (BO, SING, BRUN), as well as digitally (L, E, and K). A total of 16 *Alpinia* species are placed in the clade of *Zerumbet* classified into a section, namely section *Alpinia* were recorded in West Malesia. They share several characters: i.e. absent or caducous secondary bracts, small or reduced lateral staminodes, and often having a petaloid and showy labellum. The highest diversity of *Alpinia Zerumbet* clade is recorded in the Philippines and Borneo (each has 7 species) and the lowest diversity is in Java (2 species). The most abundant habitat is in the lowlands and mountain rainforests. Most species of *Alpinia Zerumbet* clade are found in primary forest and secondary forest (*Pinus* or *Agathis* forest). A determination key was constructed based on information in the literature and direct observations of herbarium specimens.

**Keywords:** Alpinia, diversity, Malesia, zerumbet, Zingiberaceae

## INTRODUCTION

*Alpinia* is a member of the family Zingiberaceae and naturally of the tribe Alpinioideae. The genus is native to Asia, Australia, and the Pacific Islands, occurring in tropical and subtropical climates. Several *Alpinia* species are cultivated as ornamental plants and used as spices (ASEAN 2010). Since Kress et al. (2002, 2005, 2007) classified Zingiberaceae based on molecular evidence, several legitimate genera such as *Alpinia* and *Amomum* are divided into several genera. The genus *Alpinia* is divided into six clades, namely *Galanga*, *Rafflesiana*, *Carolinensis*, *Fax*, *Eubractea*, and *Zerumbet.* Other genera such as *Amomum* and *Curcuma* are also divided into many clades, for example, *Amomum* has been divided into six genera by De Boer et al. (2018) based on fruit and anther crest shape. In addition, some members of the *Alpinia Eubractea* clade in the Philippines turned into members of the genera *Adelmeria* and *Vanoverberghia* with specific morphological characteristics (Docot et al. 2019a; 2019b). Considering the development of taxonomical knowledge of the Zingiberaceae family, research on genera that are still composed of many clades needs to be sample throughout their distribution area to support a better classification.

Malesia, a phytogeographical floristic region encompassing the Malay Peninsula, Malay Archipelago, and New Guinea, is one of the centres of *Alpinia* diversity. Research on *Alpinia* in West Malesia has been conducted since the 19th Century, such as Blume (1827), Miquel (1862), and Ridley (1899). Blume (1827) listed six *Alpinia* species in Java (*A. galanga*, *A. pyramidata* (syn. *A. galanga*), *A. javanica*, *A. malaccensis*, *A. bracteata*, *A. scabra*), one *Alpinia* species in Sulawesi (*A. rubricaulis*), and one *Alpinia* species in Moluccas (*A. gigantea*). Miquel (1862) listed three *Alpinia* species in Sumatra (*A. capitellata*, *A. galanga*, *A. mutica*), and Ridley (1899) listed eighteen *Alpinia* species in the Malay Peninsula, but one species was transferred to *Geocharis*, i.e. *G. secundiflora*. Some other researchers also explored *Alpinia* in several regions of West Malesia, such as Blume (1827), Ridley (1899, 1906, 1909), Elmer (1915), Valeton (1918), Merrill (1922), Holttum (1950), and Backer & Bakhuizen van den Brink (1968), Smith (1985), Sakai & Nagamasu (2003), Takano et al. (2003), Gobilik & Yusoff (2005), Nurainas & Junaidi (2007), Gobilik (2008), Gobilik & Limbawang (2010), Julius et al. (2010), Lamb et al. (2013), Naive (2017), Trimanto (2017), Maulidah et al. (2019), and Naive et al. (2019). They have collected, added, listed, reinstatement, reviewed, or revised of *Alpinia* species in Java, Sumatra, Malay Peninsula, Borneo, and Philippines.

Despite these studies and explorations, *Alpinia* diversity and distribution in West Malesia have not been well

documented. A sample of cases is *Alpinia* in Sumatra has only five species (Newman et al. 2004, Lamb et al. 2013). Still, the latest study reported eight species of *Alpinia* only from West Sumatra; the total number of *Alpinia* will increase in Sumatra if more exploration and studies are conducted (Fitri 2018). Moreover, this is likely to also occur in other West Malesia regions (Java, Malay Peninsula, Borneo, or the Philippines).

In addition to diversity data, taxonomic studies of *Alpinia* in the West Malesia region are also still lacking, one of which is *Zerumbet* clade (Kress et al. 2007). The *Alpinia Zerumbet* clade is dominated by species that previously belongs to the genus *Catimbium* Juss. All members of this group share two morphological characteristics: the absent of primary bract and having 1–3 flowers in a short cincinnus (Kress et al. 2007). They are distributed in tropical Asia (Indochina and West Malesia). Meanwhile, members of the *Alpinia Carolinensis* clade are distributed in East Malesia and the Pacific (Smith 1990; Santika 2011). The *Alpinia Zerumbet* clade was divided into two main subclades, namely *Zerumbet* and *Plagiostachys*. In Malesia, 19 species are placed here based on molecular data (Kress et al. 2007) wheras based on Smith older classification (1990), the *Alpinia Zerumbet* clade is composed of several subsections, such as subsection *Presleia*, *Cenolophon*, *Catimbium*, *Probolocalyx*, *Alpinia*, and *Paniculatae*. Thus, the phylogenetic relationships of these remain unclear and form polytomic branches. Due to misidentification of vouchers, Kress et al. (2007) mistakenly included two species that in actual fact belong in the Carolinensis clade: *Alpinia nutans* (Santika 2011) and *A. vulcanica* (Docot et al. 2022, in press). These species are therefore excluded here. Partial and altitudinal distribution and ecological data of *Zerumbet* clade members in this area have also not been reported in detail, even though these data are really useful as an initial reference in classification. This research aimed to analyze the diversity and distribution of *Alpinia Zerumbet* clade in West Malesia.

## MATERIALS AND METHODS

### Research materials

Several fieldworks were conducted during March 2018 to Juli 2020 in Sumatra: Bukit Barisan Selatan National Park (Lampung and Bengkulu Provinces); Java: Ujung Kulon National Park (Pandeglang District), Lebak District, Jasinga, Gunung Bunder, Halimun-Salak National Park, IPB University, CIFOR Research Forest, Munara Hill (Bogor District), Mt. Ciremai (Kuningan District), Bumiayu (Brebes District), Banyumas District, and Mt. Lawu (Karanganyar District). Specimen observations were carried out directly in the natural habitat and the Plant Resources and Ecology laboratory. The herbarium specimens of *Alpinia* clade Zerumbet were collected from previous expeditions in West Malesia (Figure 1) and stored in three herbaria, the Herbarium Bogoriense (BO), Singapore Botanic Gardens Herbarium (SING), Brunei National Herbarium (BRUN); and digital herbarium specimens from three herbaria, the Naturalis Herbarium (L), Royal Botanic Garden Edinburgh (E), and Royal Botanic Gardens Kew (K).

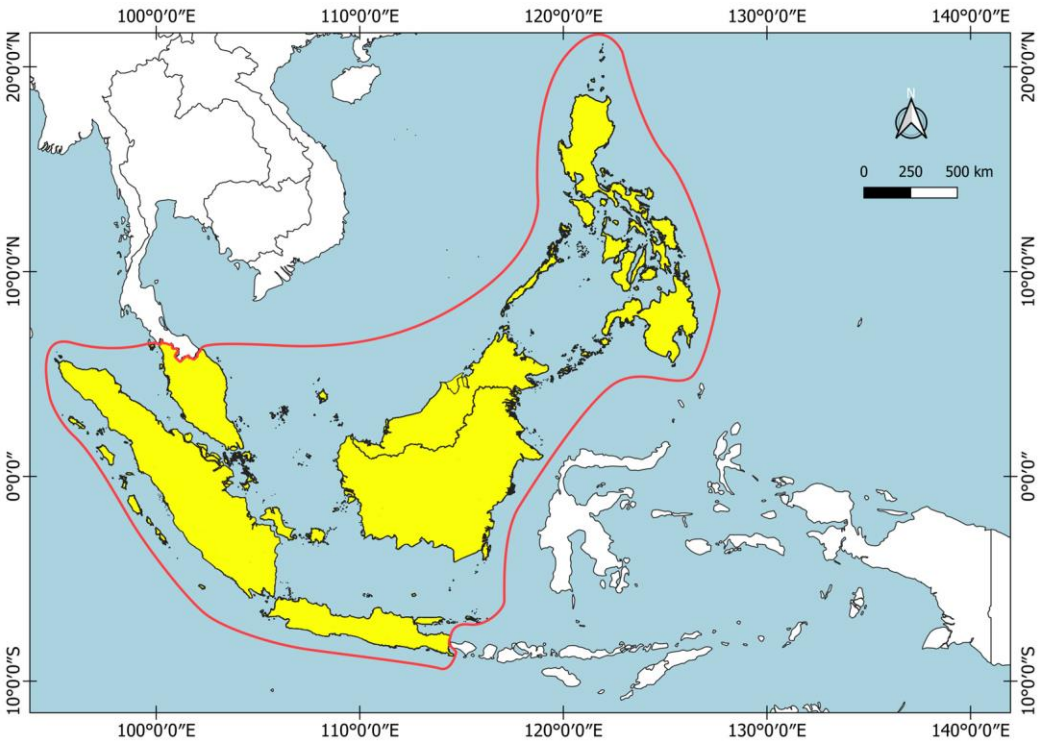


**Figure 1.** West Malesia regions (marked in red) (Wallace 1860; Maloney 1985)

**Procedures**

Specimens were collected using standard methods (Burtt & Smith 1976, Rugayah et al. 2004, Poulsen 2006) and preserved in Herbarium Bogoriense (BO). Data were recorded and documented from fresh and herbarium specimens. The specimens were then identified referring to literature on the *Alpinia* of the Malesia (Schumann 1904, Valeton 1918, Holttum 1950, Backer and Bakhuizen van den Brink 1968, Smith 1990, Poulsen 2006, Leong-Škorničková and Newman 2015), and other articles, and verified with BO specimens. Specimen observations of the Herbarium Bogoriense (BO), Singapore Botanic Gardens Herbarium (SING), Brunei National Herbarium (BRUN); and digital herbarium (Naturalis (L), Royal Botanical Garden Edinburgh (E), and Royal Botanical Garden Kew (K)) were also carried out. Abbreviations of herbarium followed Thiers (2022 [continously updated]).

**Data analysis**

An identification key to the species was developed. Morphological characters were analyzed and described. The descriptions are limited to characters that we were able to obtain from the specimens. Therefore, we have omitted several characters. For example, the growth form and height, the distance between two connected leafy shoots, and leaf sheath colour. Herbarium abbreviation followed Girmansyah et al. (2006, 2018) and website sweetgum.nybg.org (Thiers 2022, continuously updated). The accepted status of every species was determined by the following three databases: ipni.org, theplantlist.org, and plantsoftheworldonline.org. The *Alpinia Zerumbet* clade distribution pattern in West Malesia was mapped to each coordinate point of *Alpinia* in their habitats using DIVA-GIS (Hijmans et al. 2001).

## RESULTS AND DISCUSSION

**The diversity of *Alpinia zerumbet* clade in West Malesia**

Sixteen species of *Alpinia* belonging to one subgenus (subgenus *Alpinia*) have been documented in West Malesia. The highest diversity of *Alpinia Zerumbet* clade is recorded in Philippines and Borneo (7 species), followed by the Malay Peninsula (5 species), Sumatra (4 species), and Java (2 species) (Figure 2, Table 1). Several species are documented in various habitats, such as *A. aquatica*, *A. argentea*, *A. glabra*, *A. haenkei*, *A. ligulata*, and *A. malaccensis*. Other species are only found in specific habitat, such as *A. brevilabris*, *A. flabellata*, and *A. latilabris.*

Kress et al. (2007) united members of the *Alpinia Zerumbet* clade based on absent of primary bract and the number of flowers in cincinnus (1–3 flowers per-cincinnus). Meanwhile, the characters that unite the members of the *Alpinia Zerumbet* clade in West Malesia are the absent or caducous bracteoles, small or reduced lateral staminodes, and often having a petaloid and showy labellum. The primary bract of *Alpinia Zerumbet* clade is not only absent, but in some species it is persistent or caducous, such as *A. aquatica*, *A. ligulata*, and *A. nieuwenhuizii*. The flower number of *Alpinia Zerumbet* clade in West Malesia in a short cincinnus is varied (not only 1–3 flowers) from one flower per-cincinnus in *A. malaccensis* to six flowers in *A. aquatica*. So, the character uniting the members of the *Alpinia Zerumbet* clade based on Kress et al. (2007) cannot be used in this study.

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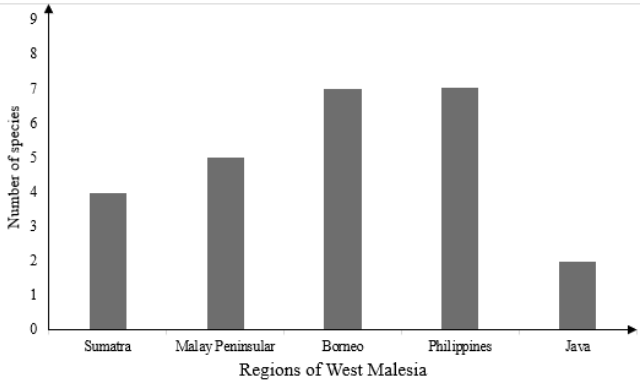


**Figure 2.** Number of species under *Alpinia zerumbet* clade in each West Malesia region

**Table 1.** List of species under *Alpinia zerumbet* clade and its habitat in the West Malesia

| Species | Presence/absence | | | | | Habitat |
|---|---|---|---|---|---|---|
| | SU | MP | BO | PH | JA | |
| *A. aquatica* | + | + | + | - | - | SF, RV |
| *A. argentea* | - | - | + | - | - | PF, KA |
| *A. brevilabris* | - | - | - | + | - | PF |
| *A. flabellata* | - | - | - | + | - | PF |
| *A. foxworthyi* | - | - | - | + | - | PF |
| *A. glabra* | - | - | + | - | - | PF, SF, RS |
| *A. haenkei* | - | - | - | + | + | SF, DS, RV |
| *A. intermedia* | - | - | - | + | - | PF |
| *A. latilabris* | + | + | + | - | - | PF |
| *A. ligulata* | - | - | + | - | - | DS, PF, RV |
| *A. malaccensis* | + | + | - | - | + | SF, RS, DS |
| *A. mutica* | + | + | + | - | - | RV, SF |
| *A. nieuwenhuizii* | - | - | + | - | - | RS, PF |
| *A. rosea* | - | - | - | + | - | PF |
| *A. sibuyanensis* | - | - | - | + | - | DS |
| *A. zerumbet* | - | + | - | - | - | SF |

Note: SU: Sumatra; MP: Malay Peninsular; JA: Java; BO: Borneo; PH: Philippines; PF: Primary Forest; SF: Secondary Forest; RS: Roadside; RV: Riverside; KA: Karst; DS: Disturbed area; + = presence; - = absence

The morphological character of labellum shape in the classification of Kress (Kress et al. (2007) is no longer a strong trait as it is in the previous classification (Smith 1990). The character cannot be used to unite members of the *Alpinia Zerumbet* clade, for example *A. aquatica, A. foxworthyi, A. flabellata, A. rosea, A. sibuyanensis* which have a labellum with four lobes (2 lateral lobes). In contrast, other species in this clade, such as *A. haenkei, A. malaccensis, A. mutica,* and *A. zerumbet* have only two lobes at the tip end. Some species even have only one lobe, as in *A. glabra, A. ligulata, A. nieuwenhuizii*. Therefore, the lobe number of labellum can be a helpful character at the level of classification below clade.

**Spatial distribution pattern of *Alpinia zerumbet* clade in West Malesia**

In general, all members of the *Alpinia Zerumbet* clade in the world are distributed in India, Indochina, and Malesia (Kress et al. 2005; 2007). The distribution of some species belonging to *Alpinia Zerumbet* clade in West Malesia are endemic for example *A. brevilabris, A. flabellata, A. foxworthyi, A. rosea,* and *A. sibuyanensis* which are endemic to the Philippines; *A. argentea, A. glabra, A. ligulata,* and *A. nieuwenhuizii* which are endemic to Borneo. Others are distributed in two or more regions.

Most *Alpinia* species are found in the Philippines, i.e *A. brevilabris, A. flabellata, A. foxworthyi, A. haenkei, A. intermedia, A. rosea, A. sibuyanensis* (Figure 3). Meanwhile, the region with the lowest number of *Alpinia* species is Java, consisting of two species, *A. haenkei* and *A. malaccensis*. *A. haenkei* is distributed in the Philippines and Java (Newman et al. 2004). But, the existing species in Java is still in doubt because there is almost no living specimen and herbarium collection indicating the occurrence of this species in Java, except Leschenhault *s.n.* collection (MNHN). This collection consisted of leaf blades, inflorescence, and illustrations of flower parts such as corolla lobes, labellum, stamen, and ovule, but the picture is similar to flower parts of *A. malaccensis*. So, we suggest that this species is only in Philippines region. Thus, we only list one species on Java Island, *A. malaccensis* (Figure 4). *A. malaccensis* is the most abundant (especially in Java and Sumatra) and evenly distributed species. *Alpinia aquatica, A. latilabris, A. malaccensis,* and *A. mutica* are found in three regions; *A. latilabris* are found in two regions, i.e. Sumatra and Malay Peninsula (Figure 5 & 6), while others are only found in one region. There are five endemic species of *Alpinia Zerumbet* clade in Philippines i.e. *A. brevilabris, A. flabellata, A. foxworthyi, A. rosea,* and *A. sibuyanensis*. Borneo has four endemic species i.e. *A.argentea, A. glabra, A. ligulata, A. nieuwenhuizii* (Figure 7).

**Altitudinal distribution *Alpinia zerumbet* clade in West Malesia**

*Alpinia Zerumbet* clade in West Malesia are distributed at elevation of 2 to 1600 m above sea level (m asl), but generally, the most potential habitat is in the lowlands and mountain rain forests. Several species of *Alpinia*, such as *A. aquatica* and *A. mutica* can be found at very low elevations, such as shorelines and river estuaries. Still, in a few cases, the *Alpinia* species can be found in higher elevations, such as *A. mutica* in streams in the lowland rain forests of Borneo (based on Susiarti S and Ce Ficker, 107 (BO)) and *A. aquatica* in mountain hiking trail of Mt. Bandahara (700 m asl), Kutajane, Aceh (de Wilde and de Wilde-Doyfjes, 12897 (BO)). *A. malaccensis* grow on coastal plains in Ujung Kulon National Park, Banten, even though these species are often found at higher elevations such as secondary forests or the foothills of mountains (Erta Fitri, 06 ALSC PNG (ANDA)). It is a possibility that several species have a wide altitudinal distribution range where they can adapt to various altitudes. There are also *Alpinia* that grow on coastal plains such as *A. malaccensis* in Ujung Kulon National Park, Banten. All species of the *Alpinia Zerumbet* clade can be found in lowland forest with an elevation between 10 and 1000 m asl, but the population number is different for each species. *Alpinia ligulata* is widely distributed between 100 and 500 m asl, but is rarely found at an elevation of 10 m asl and 1000 m asl. The *A. niewenhuizii* population is evenly distributed at every elevation, from 10 to 1200 m asl. *Alpinia* species found in above 1000 m asl are *A. foxworthyi, A. glabra, A. haenkei, A. malaccensis, A. rosea,* and *A. sibuyanensis. A. glabra*. *A. sibuyanensis* can be found at an elevation above 1400 m asl (based on JMS Clemens, 31022; ADE Elmer, 12316 (BO)) (Figure 8).

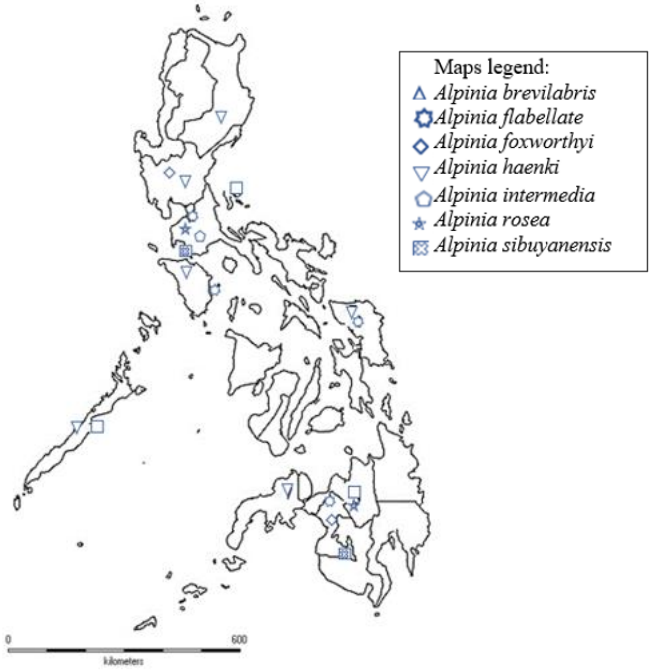


**Figure 3.** Distribution of *Alpinia zerumbet* clade in Philippines

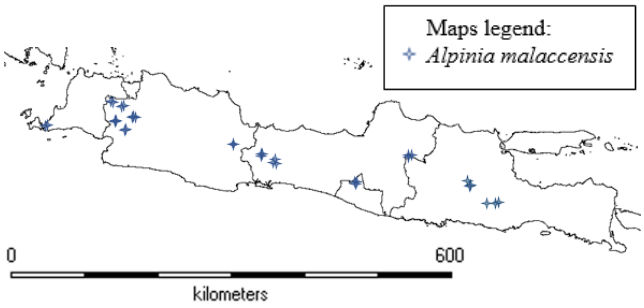


**Figure 4.** Distribution of *Alpinia zerumbet* clade in Java

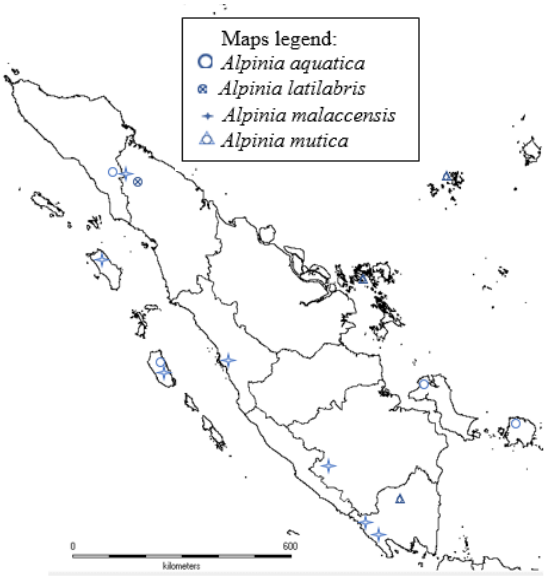


**Figure 5.** Distribution of *Alpinia zerumbet* clade in Sumatra

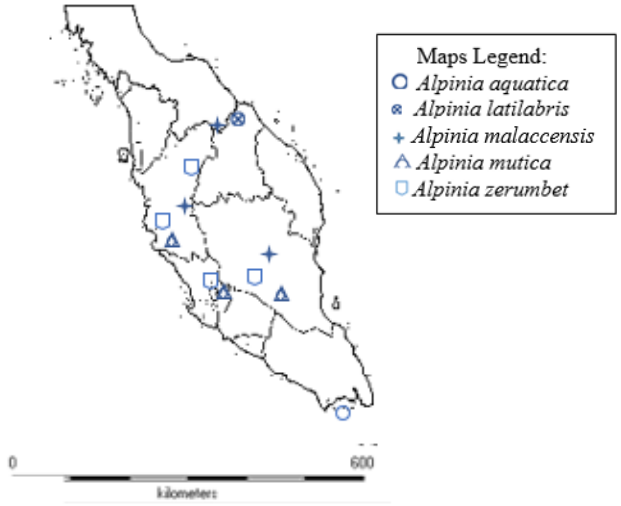


**Figure 6.** Distribution of *Alpinia zerumbet* clade in Malay Peninsula

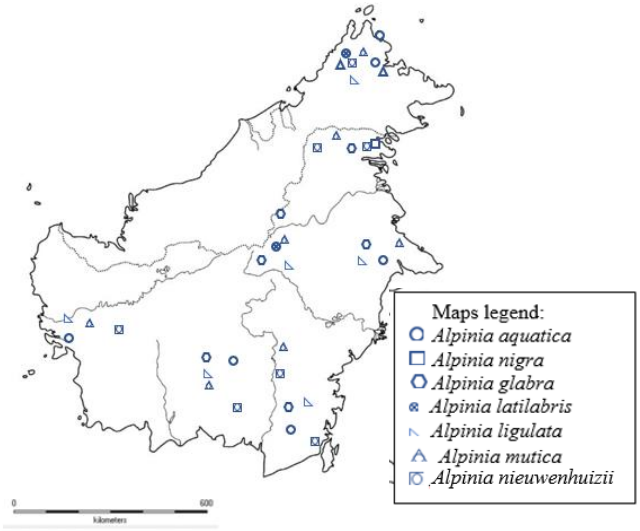


**Figure 7.** Distribution of *Alpinia zerumbet* clade in Borneo

## Habitat preference of *Alpinia zerumbet* clade in West Malesia

*Alpinia zerumbet* clade in West Malesia is found in various habitats, such as primary forest, secondary forest (*Pinus* or *Agathis* forests), roadside, riverside, limestone/karst, and disturbed areas. Commonly, most species are found in the shade or humid areas. Only a few species, such as *A. brevilabris*, have been found in limestone. There are 10 species found in the primary forest, followed by secondary forest, especially in a pine forest (6 species), riverside and disturbed area (4 species), roadside (3 species), and karst or limestone (1 species) (Figure 9).

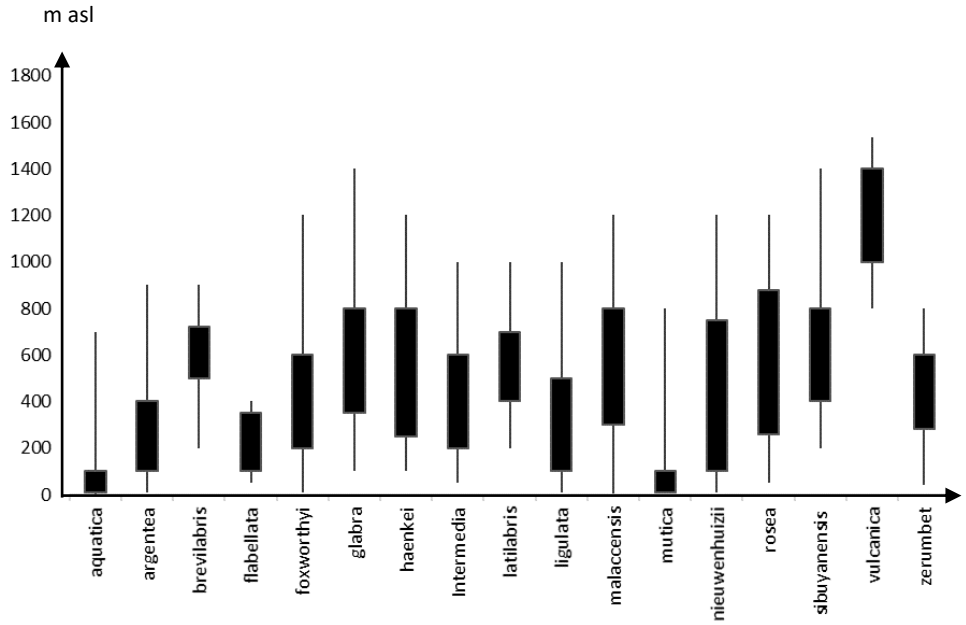


**Figure 8.** Altitudinal distribution of *Alpinia zerumbet* clade in West Malesia

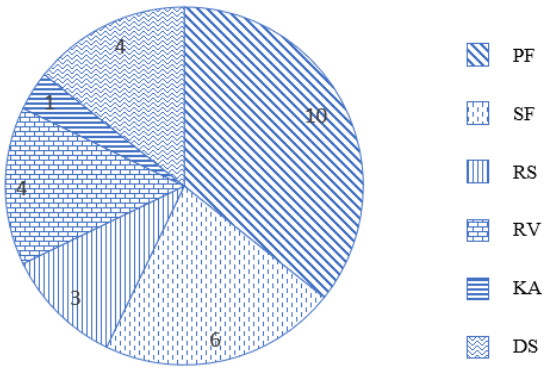


**Figure 9.** Habitat of *Alpinia zerumbet* clade in West Malesia. PF: Primary Forest; SF: Secondary Forest; RS: Roadside; RV: Riverside; KA: Karst; DS: Disturbed area. The number at figure: number of species

**Determination key of *Alpinia zerumbet* clade in West Malesia**

The determination key was made using literature from Ridley (1909), Valeton (1918), Holttum (1950), Smith (1985; 1990). In addition, the characteristics observed directly from BO, ANDA, BRUN, or online herbarium are added.

1. a. Inflorescence panicle, many branches, branches distributed throughout rachis; bract present, calyptrate ..... 2
   b. Inflorescence raceme, if branched, only 1–3 branches at the base; bract absent, minute and/ or caducous, naked ..... 3
2. a. Ligule ovate, emarginate with apex rounded, ca. 10 mm long, green, fleshy. Inflorescence erect; peduncle and rachis green; labellum lateral edges pendulous; ovary green ..... *A. nieuwenhuizii*
   b. Ligule oblong-elongated, apex acute, ca. 30–60 mm long, maroon, chartaceous. Inflorescence pendulous, peduncle and rachis maroon; labellum lateral edges erect; ovary reddish ..... *A. ligulata*
3. a. Leaf margin serrulate. Inflorescence branch 2–3 at the base; labellum lobes 4, the tip split very deep almost to the base ..... 4
   b. Leaf margin entire or ciliate. Inflorescence branch absent; labellum lobes 1, 2, or 3,the tip shallowly emarginate ..... 9
4. Leaf oblong. Calyx urceolate, lateral staminodes brown ..... *A. foxworthyi.*
   b. Leaf lanceolate, narrow lanceolate, lanceolate-oblong. Calyx tubular or campanulate; lateral staminodes green or pink ..... 5
5. a. Corolla lobes elliptic; anther crest present. Ripe fruit black or black-purplish ..... *A. aquatica*
   b. Corolla lobes oblong; anther crest absent. Ripe fruit red, orange-reddish ..... 6
6. a. Ligule membranous. Peduncle, rachis, and pedicel white-yellowish or white-pinkish; all flower parts pink-reddish ..... 7
   b. Ligule fleshy. Peduncle, rachis, and pedicel green or bright green; corolla lobes and stigma green, calyx, stylus, and stamen white ..... 8
7. a. Leaf narrow-lanceolate; flower length < 20 mm. The lateral rachis unbranched. Fruit size ca. 2-5 mm ..... *A. rosea*

b. Leaf oblong-lanceolate; flower length ≥ 20 mm; The lateral rachis short branched Fruit size ca. ≥ 10 mm ..... *A. sibuyanensis*

8. a. Leaf oblong-lanceolate. Lateral staminodes spiny horizontally ..... *A. flabellata*
   b. Leaf lanceolate. Lateral staminodes spiny vertically ..... *A. brevilabris*
9. a. Bracteoles absent; flowers strictly single (not in cincinni), almost all parts yellow ..... *A. argentea.*
   b. Bracteoles present; flowers in cincinni, flower parts color varies (white, yellow, or red) ..... 10
10. a. Bracteoles partially enclosing the buds; labellum white with two red strips in the central; lateral staminodes present, curved back, ca. ≥ 5 mm long ..... *A. intermedia*
    b. Bracteoles completely enclosing the buds; labellum yellow with red stripes; lateral staminodes absent or reduced, if present, small, ca. < 5 mm long ..... 11
11. a. Bracteoles calyptrated; all inflorescence parts red; calyx not deeply split unilaterally ..... *A. glabra*
    b. Bracteoles naked; inflorescence parts color varies (peduncle and rachis green or yellow-greenish, flower white or yellow); calyx deeply split unilaterally ..... 12
12. a. Inflorescence pendulous; peduncle and rachis maroon. Fruits grooved ..... *A. zerumbet*
    b. Inflorescence erect; peduncle and rachis green or green yellowish. Fruit smooth ..... 13
13. a. Leaves narrow-lanceolate, petiole ca. < 10 mm long (subsessile). Lateral staminodes absent (spurless) ..... *A. mutica*
    b. Leaves oblong-lanceolate. petiole ca. ≥ 10 mm long. Lateral staminodes reduced to fleshy swelling ..... 14
14. a. Ligule sub-acute, entire. Leaves glabrous on both sides. Labellum cordate. Fruit nearly glabrous ..... *A. latilabris*
    b. Ligule ovate, emarginate. Leaves hairy on abaxial or adaxial side only or both sides. Labellum broadly ovate. Fruit pubescent ..... 15
15. a. Leaves hairy on both sides or adaxial side only, margin very wavy. Pedicel ca. ≥ 10 mm long. Fruit globose or ellipsoid ..... *A. haenkei*
    b. Leaves hairy on abaxial side only, margin entire or rarely wavy. Pedicel ca. < 10 mm long. Fruit subglobose ..... *A. malaccensis*

**Species diagnostic description of *Alpinia zerumbet* clade in West Malesia**

***Alpinia aquatica*** (Retz.) Roscoe, Trans. Linn. Soc. London 8 (1807) 346. — Basionym: *Heritiera aquatica* Retz., Observ. bot. 6 (1791) 18. — Type: *J.G. König s.n.*, specimen lost.

Ligule ovate with rounded apex, fleshy; petiole subsessile ca. 5–10 mm long; lamina lanceolate, glabrous on both sides, margin serrulate. Inflorescence raceme, erect, lateral branches 2–3 at the base; peduncle and rachis glabrous, bright green; pedicel ca. 1–2 mm long; bract caducous, naked; bracteole absent; flowers 2–6 in a cincinnus, white with pink; calyx tubular, a bit split at the tip; lateral corolla lobes elliptic, lobes tip rounded, white; lateral staminodes present, erect, pink; labellum obovate, a bit curved up, the tip split very deep almost to the base, lobes 4, lateral lobes perpendicular and narrower than tip lobes, margin entire, pink purplish; anther crest present. Fruit globose, ca. 5 mm, smooth, glabrous, black.

***Alpinia argentea*** (B.L. Burtt & R.M. Sm.) R.M. Sm., Bot. J. Linn. Soc. 85 (1982) 69. — Basionym: *Cenolophon argenteum* B.L. Burtt & R.M. Sm., Notes Roy. Bot. Gard. Edinburgh 31 (1972) 310. — Type: *B.L. Burtt & A.M. Martin 5166* (holo E!), Gunung Murud.

Ligule bilobed, fleshy; petiole subsessile ca. 5–10 mm long; lamina lanceolate, glabrous on both sides, margin entire. Inflorescence raceme, erect, no lateral branch; peduncle and rachis glabrous, yellow; pedicel ca. 1–2 mm long; bract minute, caducous, naked; bracteole absent; flower not in cincinni, yellow; calyx tubular, split up to the center; lateral corolla lobes oblong, lobes tip rounded, yellow; lateral staminodes present, erect, curved sideaways, base red, tip yellow; labellum obovate, curved up, lobes 3, margin undulate, the tip is slightly tufted, serrate, shallowly emarginate, yellow with red stripees at the center; anther crest present. Fruit globose, ca. 20 mm, smooth, glabrous, red.

***Alpinia brevilabris*** C. Presl, Reliq. haenk. 1 (1827) 110. — *Languas brevilabris* (C. Presl) Merr., Enum. Philipp. fl. pl. 1 (1923) 230. – Type: *T. Haenke s.n.* (PR!).

Ligule ovate with rounded apex, fleshy; petiole subsessile ca. 5–10 mm long; lamina lanceolate, glabrous on both sides, margin serrulate. Inflorescence raceme, erect, lateral branches 2–3 at the base; peduncle and rachis glabrous, light green-green; pedicel ca. 1–2 mm long; bract caducous, naked; bracteole absent, flowers 2–4 in a cincinnus, almost all parts light green; calyx tubular, a bit split; lateral corolla lobes oblong, green, a bit transparent, lobes tip rounded; lateral staminodes present, erect, spiky, pink; labellum obovate, a bit curved up, lobes 4, lateral lobes is very close and same size as tip lobes, margin entire, the tip split very deep almost to the base, white-greenish transparent and pink-purplish at the center; anther crest absent. Fruit globose-ellipsoid, ca. 5 mm, smooth, glabrous, red.

***Alpinia flabellata*** Ridl., Philipp. J. Sci., C 4 (1909) 188. — *Languas flabellata* (Ridl.) Merr., Enum. Philipp. fl. pl. 1 (1923) 231. — Type: *E.D. Merrill 1878* (syn K!), *2226* (syn K!).

Ligule ovate with rounded apex, fleshy; petiole subsessile ca. 5–10 mm long; lamina oblong-lanceolate, glabrous on both sides, margin serrulate. Inflorescence raceme, erect, lateral branches 2–3 at the base; peduncle and rachis glabrous, bright green; pedicel ca. 1–2 mm long; bract minute, caducous, naked; bracteole absent; flowers 2–4 in a cincinnus, dominated white and green; calyx tubular, a bit split; lateral corolla lobes oblong, lobes tip elliptic, green with a bit transparent; lateral staminodes present, spiny horizontally, green with a little red; labellum obovate, a bit curved up, lobes 4, lobes subequal lateral lobes is wider than tip lobes and all rounded, margin entire,

the tip split very deep almost to the base, white with pink at the center. Fruit globose, ca. 5 mm, smooth, glabrous, red.

***Alpinia foxworthyi*** Ridl., Philipp. J. Sci., C 4 (1909) 189. — *Languas foxworthyi* (Ridl.) Merr., Enum. Philipp. fl. pl. 1 (1923) 231. — Type: *F.W. Foxworthy 772* (holo SING!, iso BO!, E!, K), Palawan.

Ligule ovate with rounded apex, fleshy; petiole subsessile ca. 5–10 mm long; lamina oblong, glabrous on both sides, margin serrulate. Inflorescence raceme, erect, glabrous, lateral branches 2–3 at the base; peduncle and rachis glabrous, green yellowish; pedicel ca. 1–2 mm long; bract minute, caducous, naked; bracteole absent; flowers 2–4 in a cincinnus, dominated with white; calyx urceolate (swell), a bit split; lateral corolla lobes elliptic, lobes tip rounded, white; lateral staminodes present, erect, spiky, brown; labellum obovate, a bit curved up, lobes 4, lateral lobes rounded and wider than tip lobes, margin entire, tip split very deep almost to the base, white creamy with pink-purplish at the center; anther crest present. Fruit globose, ca. 5 mm, smooth, glabrous, black-purplish.

***Alpinia glabra*** Ridl., J. Straits Branch Roy. Asiat. Soc. 32 (1899) 168. — *Languas glabra* (Ridl.) Merr., Univ. Calif. Publ. Bot. 15 (1929) 34. — Lectotype: *G.D. Haviland 444* (K, designated by Burtt & Smith, 1972, isolecto SAR!), Santubong.

Whole plant almost completely glabrous. Ligule shallowly emarginate with rounded apex, fleshy; petiole ca. 40–75 mm long; lamina oblong-lanceolate, glabrous on both sides, margin entire; Inflorescence raceme, erect, lateral branches 2–3 at the base; peduncle and rachis glabrous, red-maroon; pedicel ca. 3–5 mm; bract caducous, naked; bracteole caducous, completely enclosing the buds, calyptrate; flowers 1–3 in a cincinnus; calyx tubular gradually dilated upward, a bit split at the tip; lateral corolla lobes oblong, bright red, lobes tip rounded; lateral staminodes present, erect; labellum oblong, boat-shaped, curved up, 2 lobes, bright red-maroon at the center margin undulate from center to the tip, tip shallowly emarginate; anther crest present. Fruit subglobose, ca. 20 mm, smooth, glabrous, red.

***Alpinia haenkei*** C. Presl, Symb. bot. (1832) 66, t. 43. — *Languas haenkei* (C. Presl) Merr., Enum. Philipp. fl. pl. 1 (1923) 232. — *Catimbium haenkei* (C. Presl) M.L. Steiner, Philippine ornamental plants and their care (1960) 206. — Type: *T. Haenke s.n.* (PR!).

Ligule ovate with shallowly emarginate apex, fleshy; petiole ca. 20-40 mm long; lamina oblong-lanceolate, pubescent on both surfaces or glabrous above, cilliate and very wavy. Inflorescence raceme, erect, no lateral branch; peduncle and rachis silky, green-yellowish, light green; pedicel ca. 11–15 mm long; bract absent, naked; bracteole caducous, completely enclosing the buds, naked; flowers 1–2 in a cincinnus, dominated white except labellum; calyx campanulate, split to the base; lateral corolla lobes oblong, lobes tip rounded, white; lateral staminodes reduced to fleshy swelling; labellum broadly ovate, curved up, 3 lobes, lateral lobes hardly distinct, margin undulate from center to the tip, tip oblong, truncate, narrower, crisped and shallowly emarginate, orange-yellow with red at the center, red spots and stripes up to the tip; anther crest absent. Fruit globose or ellipsoidca. 20–30 mm, smooth, pubescent, orange-red.

***Alpinia intermedia*** Gagnep., Bull. Soc. Bot. France 48(Sess. Extraord.): lxxxii (1902). — *Languas intermedia* (Gagnep.) Sasaki, Trans. Nat. Hist. Soc. Formosa 18: 175 (1928). — Type: *R. P. Ferrié s.n.* (P00686645—holo, K000815869—iso), Ryukyu islands, Japan

Ligule oblong with shallowly emarginate apex, fleshy; petiole ca. 10–20 mm long; lamina oblong, glabrous on both sides, margin entire. Inflorescence raceme, erect, no lateral branch; peduncle and rachis glabrous, green or maroon; pedicel ca. 5–10 mm long; bract caducous, naked; bracteole caducous, partially enclosing the buds, naked; flowers 1–3 in a cincinnus, white; calyx tubular, a bit split; lateral corolla lobes oblong, lobes tip rounded, white; lateral staminodes present, erect, curved back, white with red pattern; labellum ovate-oblong, curved up, 1 lobes, margin entire, tip shallowly emarginate, white with two red stripes (at the middle) from the base to the tip; anther crest absent. Fruit elongated globose, ca. 5 mm, smooth, glabrous, red.

***Alpinia latilabris*** Ridl., J. Straits Branch Roy Asiat Soc 32 (1899) 168. — *Catimbium latilabre* (Ridl.) Holttum, Gard. Bull. Singapore 13 (1950) 153. – Lectotype: *H.N. Ridley s.n. (August 1891)* (SING, designated by Turner, 2000), Pahang.

Ligule sub-acute with shallowly emarginate apex, fleshy; petiole ca. 40–70 mm long; lamina oblong-lanceolate, glabrous on abaxial side only or both sides, except the midrib and petiole hairy, margin cilliate. Inflorescence raceme, erect, no lateral branch; peduncle and rachis pubescent, green; pedicel 5–10 mm; bract absent, naked; bracteole caducous, completely enclosing the buds, naked; flowers 1–2 in a cincinnus, white except labellum; calyx campanulate, split to the base; lateral corolla lobes oblong, white, lobes tip rounded; lateral staminodes reduced to fleshy swelling; labellum cordate, curved up, 3 lobes, lateral lobes not distinct, shallowly emarginate and undulate at the tip, center orange densely spotted with red stripes up to tip, edge yellow; anther crest absent. Fruit globose, ca. 20–30 mm, smooth, nearly glabrous, orange.

***Alpinia ligulata*** K. Schum., Bot. Jahrb. Syst. 27 (1899) 275. — *Languas ligulata* (K. Schum.) Merr., Univ. Calif. Publ. Bot. 15 (1929) 33. — Lectotype: *O. Beccari 987* (FI!, designated by Sakai & Nagamasu, 2003), Sarawak.

Ligule oblong elongated (up to 60 mm long) with acute apex, chartaceous, maroon; petiole ca. 50–100 mm long; lamina oblong-lanceolate, glabrous on both sides, margin entire. Inflorescence panicle, pendulous, much branches throughout rachis; peduncle and rachis glabrous, maroon; pedicel ca. 1–3 mm long; bract present, calyptrated; bracteole absent; flower 1 in a cincinnus, yellow-red; calyx tubular, not split; lateral corolla lobes oblong, curved, lobes tip acute (hooded), yellow-reddish; lateral staminodes present, erect, curved back, red or maroon; labellum obovate, curved up, lobe 1, a bit undulate at the edge and tip, center white with red at the base, closely red stripes along the lip from center to the edges; anther crest present.

Fruit globose, ca. 20 mm, smooth, glabrous, orange-yellowish.

***Alpinia malaccensis*** (Burm. f.) Roscoe, Trans. Linn. Soc. London 8 (1807) 345. — Basionym: *Maranta malaccensis* Burm. f., Fl. indica (1768) 2. — *Languas malaccensis* (Burm. f.) Merr., Philipp. J. Sci. 19 (1921) 343. — *Catimbium malaccense* (Burm. f.) Holttum, Gard. Bull. Singapore 13 (1950) 155. — Type: Herb. amboin. 5: 176, t, 71, f. 1 (1747).

Ligule ovate with shallowly or deeply emarginate apex fleshy; petiole ca. 50–100 mm long; lamina oblong-lanceolate, glabrous on adaxial and pubescent on abaxial, margin cilliate and rarely wavy. Inflorescence raceme, erect, no lateral branch; peduncle and rachis silky, green; pedicel ca. 4–8 mm long; bract absent or caducous; bracteole caducous, completely enclosing the buds, naked; flower 1(–3) in a cincinnus, dominated white except labellum; calyx campanulate, split to the base; lateral corolla lobes oblong, lobes tip rounded, white; lateral staminodes reduced to fleshy swelling; labellum broadly ovate, curved up into a tube, lobes 3, undulate almost from the base up to the tip, the tip shallowly emarginated and tufted, yellow, red-dark red at the center with red stripes up to the tip (occasionally up to the yellow stripes); anther crest absent. Fruit subglobose, ca. 20–40 (–60) mm, smooth, pubescent, orange or red.

***Alpinia mutica*** Roxb., Asiat. Res. 11 (1810) 354. - *Renealmia mutica* (Roxb.) Salisb., Trans. Hort. Soc. London 1 (1812) 280. — *Languas mutica* (Roxb.) Merr., Univ. Calif. Publ. Bot. 15 (1929) 35. — *Catimbium muticum* (Roxb.) Holttum, Gard. Bull. Singapore 13 (1950) 150. — Type: *Icones Roxburghianae 1929* (CAL).

Ligule oblong with acute apex, fleshy; petiole subsessile ca. 5–10 mm long; lamina narrow-lanceolate, glabrous on both sides, margin cilliate. Inflorescence raceme, erect, no lateral branch; peduncle and rachis glabrous, green, velvety; pedicel ca. 4–8 mm long; bract absent; bracteole caducous, completely enclosing the buds, naked; flowers 1–3 in a cincinnus, almost white except labellum; calyx campanulate, split to the base; lateral corolla lobes oblong, lobes tip rounded, white; lateral staminodes absent/spurless; labellum ovate, curved up, lobes 3, a bit undulate at the tip, the tip shallowly tufted, yellow-bright gold with red spots and stripes at the center; anther crest absent. Fruit subglobose, ca. 20–30 mm, smooth, nearly glabrous, orange-reddish.

***Alpinia nieuwenhuizii*** Valeton, Bull. Inst. Bot. Buitenzorg 20 (1904) 86. — Type: *A.W. Nieuwenhuis 1362* (holo BO!), Kalimantan.

Ligule ovate with emarginate apex (ca. 10 mm long), green, fleshy; petiole ca. 20–50 mm long; lamina oblong, glabrous on both sides, margin entire. Inflorescence panicle, erect, much branches throughout rachis; peduncle and rachis glabrous, green; pedicel ca. 1–3 mm long; bract present, calyptrated; bracteole absent; flower 1 in a cincinnus, dominated yellow-red; calyx tubular, not split; lateral corolla lobes oblong, lobes tip acute (hooded), yellow-reddish; lateral staminodes present, erect, spiky, pink; labellum obovate-oblong, lateral edges curved down, lobe 1, a bit undulate at the edge and the tip, tip shallowly tufted, white with red at the base, closely pink stripes along the lip from the center to the edges; anther crest absent. Fruit globose, ca. 20–30 mm, smooth, glabrous, orange-yellowish.

***Alpinia rosea*** Elmer, Leafl. Philipp. Bot. 8 (1915) 2890. — *Languas rosea* (Elmer) Merr., Enum. Philipp. fl. pl. 1 (1923) 233. — Type: *A.D.E. Elmer 12509* (iso E!, L!).

Ligule ovate with rounded apex, membranous; petiole subsessile ca. 5–10 mm long; lamina narrow-lanceolate, glabrous on both sides, margin serrulate. Inflorescence raceme, erect, lateral branches 2–3 at the base; peduncle and rachis glabrous, yellow-pinkish; pedicel ca. 1–2 mm long; bract caducous, naked; bracteole absent; flower 1–4 in a cincinnus, almost pink-red; calyx tubular, split to the center; lateral corolla lobes oblong, lobes tip rounded, pink; lateral staminodes present, erect, small triangle, pink; labellum obovate, a bit curved up, lobes 4, lateral lobes is narrower than tip lobes, margin entire, the tip split very deep almost to the base, pink, pink-reddish at the center; anther crest absent. Fruit globose, 2–5 mm, smooth, glabrous, red-purplish.

***Alpinia sibuyanensis*** Elmer, Leafl. Philipp. Bot. 8 (1915) 2891. — *Languas sibuyanensis* (Elmer) Merr., Enum. Philipp. fl. pl. 1 (1923) 234. — Type: *A.D.E. Elmer 12316* (iso BO!, E!, FI!, G!), Sibuyan, Mt. Guiting-guiting, Magallanes.

Ligule ovate with rounded apex, membranous; petiole subsessile ca. 5–10 mm long; lamina oblong-lanceolate, glabrous on both sides, margin serrulate. Inflorescence raceme, erect, lateral branches 2–3 at the base; peduncle and rachis glabrous, yellow; pedicel ca. 1–2 mm long; bract caducous, naked; bracteole absent; flowers 1–4 in a cincinnus, ca. 20 mm long (as a comparison, *A. rosea* flower ca. 10 mm long), pink-red; calyx tubular, split to the center; lateral corolla lobes oblong, lobes tip elliptic, pink; lateral staminodes present, erect, pink; labellum obovate, a bit curved up, lobes 4, lateral lobes is narrower than tip lobes, margin entire, the tip split very deep almost to the base, white-pinkish with pink reddish at the center, pink reddish stripes; anther crest absent. Fruit globose, ca. 10 mm long, smooth, glabrous, scarlet.

***Alpinia zerumbet*** (Pers.) B.L. Burtt & R.M. Sm., Notes Roy. Bot. Gard. Edinburgh 31 (1972) 204. — Basionym: *Zerumbet speciosum* J.C. Wendl., Sert. hannov. 1 (1798) 3, t. 19. — *Costus zerumbet* Pers., nom. nov., Syn. pl. 1 (1805) 3. - *Alpinia speciosa* (J.C. Wendl.) K. Schum., nom. illeg., Fl. Kais. Wilh. Land (1889) 29. — *Languas speciosa* (J.C. Wendl.) Small, Fl. s. e. U. S. 2 (1913) 307. — *Catimbium speciosum* (J.C. Wendl.) Holttum, Gard. Bull. Singapore 13 (1950) 152. — Type: *J.C. Wendland s.n.* (GOET).

Ligule oblong with obtuse apex, fleshy; petiole subsessile ca. 5–10 mm long; lamina lanceolate, glabrous on both sides, margin entire. Inflorescence raceme, pendulous; peduncle and rachis silky, maroon-velvety; pedicel ca. 4–8 mm long; bract absent or caducous, naked; bracteole caducous, completely enclosing the buds, naked; flowers 3 in a cincinnus, almost white except labellum; calyx campanulate, split to the base; lateral corolla lobes oblong, lobes tip rounded, white; lateral staminodes

reduced to fleshy swelling; labellum ovate, curved up, lobes 3, the tip undulate, shallowly emarginated and tufted, yellow with bright red at the center, red stripes up to the tip; anther crest absent. Fruit ovate, ca. 20 mm, grooved, glabrous, orange-reddish.

To conclude, there are 16 species of *Alpinia* clade *Zerumbet* in West Malesia. They share four characters: absent or caducous secondary bracts, small or reduced lateral staminodes, and often having a petaloid and showy labellum. The absent of primary bract previously used for uniting the members of the *Alpinia zerumbet* clade cannot be used in this study because the character of several species varies, not only absent but also present or caducous as in *A. ligulata*, *A. nieuwenhuizii*, and *A. sibuyanensis*. Then, the number of flowers in a short cincinnus is various (not only 1–3 flowers), one flower per-cincinnus as in *A. malaccensis*, or six flowers in *A. aquatica*. Several characters can be used to distinguish between species, which are rhizome odors; ligule shapes and sizes; leaf shapes and leaf margin types; inflorescence types; peduncle sizes and color; bract or bracteole shapes and color, number of flowers in cincinni; labellum shape, contour, and color; presence and shape of lateral staminodes; ovary shape, contour, indumentum, and color. They are distributed over a wide altitudinal range, from 0 to 1600 m asl. These species generally grow in primary and secondary forests. *A. latilabris*, *A. malaccensis*, and *A. mutica* have the widest distribution with three regions. *A. argentea*, *A. ligulata*, *A. glabra*, and *A. nieuwenhuizii* are endemic to Borneo. *A. flabellate* and *A. foxworthyi* only occur in Palawan Island, while *A. rosea*, and *A. sibuyanensis* are endemic to the Philippines. In contrast, *A. malaccensis* is the most abundant species, especially in Java and Sumatra. Suggestions for further research are that it's necessary to carry out further analysis on the diversity of molecular morphology, distribution, and other data so that the classification of *Alpinia* in the future will be better.

## ACKNOWLEDGEMENTS

We thank the Head and all staff of the Bukit Barisan Selatan National Park, Mt Ciremai National Park, Mt Halimun-Salak National Park, Ujung Kulon National Park, Bromo Tengger Semeru National Park, Natural Resources Conservation Center or BKSDA (Balai Konservasi Sumber Daya Alam), for the opportunity and convenience given to us when carrying out the exploration. We thank the Ministry of Education and Culture of the Republic of Indonesia (KEMENDIKBUD-RISTEK) for financial support through BPPTN grant scheme in 2018-2020. We also thank the Head and all staff of Herbarium Bogoriense, Brunei Herbarium, Singapore Herbarium, and Andalas Herbarium for all the help and ease of access to the herbarium specimen during this study.

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