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Research Article

Species Composition and Assessment of Zingiberaceae in the Forest Patches of Mt. Musuan, Bukidnon, Southern Philippines

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ABSTRACT

This study documented 11 species of gingers belonging to nine genera distributed in three tribes and two subfamilies from Mt. Musuan and its vicinity in Bukidnon, Southern Philippines. Data revealed that Zingiberaceae species in these sites constitute *ca.* 8% of the total number of Philippine Zingiberaceae. *Alpinia haenkei* C.Presl., *A. purpurata* (Vieill.) K.Schum., *Curcuma zedoaria* (Christm.) Roscoe, *Etlingera philippinensis* (Ridl.) R.M.Sm., *Hornstedtia conoidea* Ridl., *Meistera muricarpa* (Elmer) Škorničk. & M.F.Newman, and *Zingiber zerumbet* (L.) Smith. were recorded in Mt. Musuan, while *Amomum dealbatum* Roxb., *Etlingera elatior* (Jack) R.M.Sm., *Hedychium coronarium* Koenig, *Hornstedtia conoidea* Ridl., and *Wurfbainia elegans* (Ridl.) Škorničk. & A.D.Poulsen. were collected in CMU View Deck in Kibulawan. Of the collected species, five of these (3.52% endemicity compared to the total number of Philippine Zingiberaceae) are endemic to the Philippines, while the other six species are introduced. These species are mostly associated with fern species, such *Dicranopteris linearis* (Burm.f.) Underw. and *Lygodium circinnatum* (Burm.f.) Sw., and angiosperms *Musa textilis* and under the shades of dipterocarpaceae species. This paper is the first taxonomic report on Zingiberaceae in Mt. Musuan and vicinity which was not documented in the previous studies conducted at Philippine Long Term Ecological Research (LTER) Sites. Since Mt. Musuan is not a protected area and an open site for ecotourism which is constantly visited by daily hikers, these species might be prone to depletion in their wild habitats. There is an urgent call for *in situ* conservation efforts that should be done by the concerned authorities of Central Mindanao University to help preserve and protect these ginger species.

Keywords: Alpinieae; Gingers; Invasive species; Mt. Kalayo; Philippine endemic

Introduction

The Zingiberaceae family is comprises of over 1,500 species distributed in at least 53 genera (Kress et al., 2002; Lamb et al., 2013; Christenhusz and Bying, 2016). Nineteen genera and 142 species of Zingiberaceae have been recorded so far in the Philippines (Pelser et al., 2011 onwards). Members of this family played a significant role in daily needs of human beings since the time of Linnaeus because of the benefits they offered, such as for food, medicine, spices, cosmetics and ornaments (Van Balgooy, 2001; Newman et al., 2004; Prabhukumar et al., 2015). The Philippine Zingiberaceae is an interesting family to study in terms of its taxonomic status, because since 2017, there were several reports of new species an new species records added to this family.

Mt. Musuan, also known as Mt. Kalayo, is one of the five Long Term Ecological Research (LTER) Sites in Mindanao. The established 2-ha LTER permanent plot is located at the lowland mixed dipterocarp/agroecosystem of Mt. Musuan at 388 masl. The establishment of the Mindanao LTER Sites is in response to the global campaign to move towards a more sustainable world in which the health of the ecosystem and human well-being are improved (Acma et al., 2018). During the previous LTER studies conducted on inventory of flowering plants in the permanent plot of Mt. Musuan, Zingiberaceae species were not included, and thus, no species of this group were recorded inside the 2-ha permanent plot and no species of gingers were reported to occur in its nearby forest patches, including the CMU view deck. Thus, this study was commenced to revisit the LTER Site as well as the forest patches of Mt. Musuan to conduct an inventory and assessment of Zingiberaceae species.

Materials and Methods

Study Sites and Description

This study was conducted in the forest patches of Mt. Musuan from January – March 2023 (**Figure 1**). Mt. Musuan (7º 52' 56.58" N 125º 3' 55.38" E) is also known as Mt. Kalayo and has deciduous tree species, which means that their leaves shed off at the same time leaving the tree temporarily bare for a certain time of the year (Acma et al., 2018). This mountain is composed of fragmented secondary forests and is dominated by some trees, such as dipterocarp species (Dipterocarpaceae), *Senna spectabilis* (DC.) H.S.Irwin & Barneby (Fabaceae), *Alstonia scholaris* (L.) R.Br. (Apocynaceae), and *Artocarpus blancoi* (Elmer) Merr. (Moraceae). The area is currently afflicted by the presence of some invasive species, such as *Chromolaena odorata* (L.) R.M.King & H.Rob. and *Lantana camara* L. (Asteraceae), *Donax canniformis* (G.Forst.) K.Schum.

(Marantaceae), *Spathodea campanulata* P.Beauv. (Bignoniaceae), and Piper aduncum L. (Piperaceae).

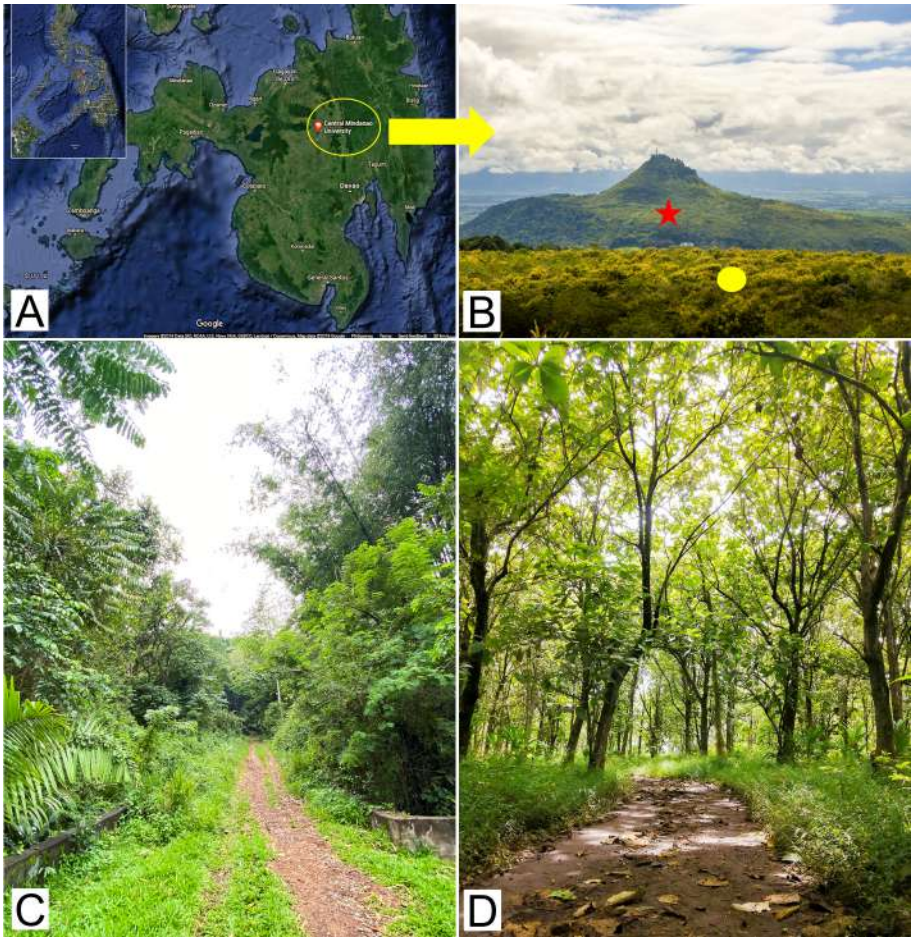

Figure 1. Study site. **A)** Map of Mindanao Island (inset: Philippine map), **B)** study sites (red star – Mt. Musuan; yellow circle – CMU view deck), **C)** trail to Mt. Musuan, **D)** trail to CMU View Deck. *Photographs: A - Google map ©2023; B&D - Rodel Tubongbanua; C - Noe P. Mendez.*

On the other hand, the CMU View Deck, located in Kibulawan (7º 89' 11.82" N 125º 5' 31.30" E) was just recently opened for ecotourism activities in Bukidnon due to its scenic view. The CMU View Deck is accessible since the peak can be reached by walking for approximately 40 minutes from the highway and by using 4-wheel-drive vehicles from the entrance of Sayre Highway to the peak. CMU View Deck is also known as a Station of the Cross site during Holy Week because

the stations are located along the trail, adding to its popularity and accessibility to hikers/mountaineers. Some planted crops were observed to occur along the trail, such as *Cocos nucifera* L. (Arecaceae), *Musa textilis* Née (Musaceae), Hevea brasiliensis (Willd. ex A.Juss.) Müll.Arg. (Euphorbiaceae), and *Falcataria falcata* (L.) Greuter & R.Rankin (Fabaceae).

Sampling Techniques

Floristic surveys were carried out in Mt. Musuan and its vicinity to inventory the Zingiberaceae species present in these areas. These were done through repeated transect walks and opportunistic samplings in the two sites from Sayre Highway to the peak. Inventory inside the established 2-ha permanent plots was also done. Sterile species that were identifiable up to genera and species levels were also recorded.

Collection, Processing and Identification of Specimens

Collection of species was limited to only three pieces of plant parts per species per site as stipulated in the gratuitous permit. Representative vegetative plant parts from the terminal part, middle, and basal portions of the plant body were prepared. Collected specimens were numbered and documented as to the collector, date of collection, locality, common name, habitat, height and inflorescence. Species were collected for voucher purposes and the specimens were processed following the wet method, dried using a mechanical dryer, and the corresponding labels were affixed and herbarium specimens were deposited at the Central Mindanao University Herbarium (CMUH). Likewise, pickled collections of the floral parts were placed inside small plastic containers and preserved using 70% ethanol and pure glycerine which comprised about 10% of the total preservation mixture.

Field guides, online database (e.g. JSTOR), online e-Flora (e.g., Co's Digital Flora of the Philippines by Pelser et al., 2011 onwards), protologues (e.g., Ridley, 1909; Elmer 1915; Elmer, 1919), and published literature were used to identify the collected specimens. The assessment of endemism was based from Pelser et al. (2011 onwards).

Assessment of Conservation Status and Endemism

The conservation status was based on Fernando et al. (2022) and online websites of CITES (2023) and IUCN (2023). The assessment of endemism of each species was based on Pelser et al. (2011 onwards).

Results and Discussion

Species Composition

This study revealed a total of 11 species of Zingiberaceae belonging to 2 subfamilies, 3 tribes, and 9 genera (**Table 1; Figure 2**). The collected species is similar to the findings of Jayme et al. (2020) with 11 species, but lower than the studies of Naive (2017) with 12 species, Dalisay et al. (2018) with 23 species, Acero et al. (2019) with 14 species, and Acma et al. (2020) with 27 species. This study is the 6th report on taxonomic inventory of Philippine Zingiberaceae in a mountain ecosystem. This study is also consistent to the earlier reports of Naive (2017), Dalisay et al. (2018), Acero et al. (2019), Jayme et al. (2020), and Acma (2020) which collected the majority of species belonging to Tribe Alpinieae. Based on the repeated fieldwork conducted by the first author from 2017 to present in different mountain ecosystems and forest patches in Mindanao, it was observed that species of Tribe Alpinieae frequently occur and dominated the forest patches compared to other tribes. This claim is supported by a new genus record in the Philippines – *Sulettaria* A.D.Poulsen and Mathisen; new species reported in the Philippines – *Alpinia*, *Etlingera*, and *Hornstedtia*; and new species and a new record of *Plagiostachys*, in which all of these species are under the Tribe Alpinieae.

Table 1. Subfamilies, tribes and genera of the collected Zingiberaceae species.

No.	Subfamily	Tribe	Genus	No. of Species
1	Alpinioideae	Alpinieae	*Alpinia*	2
2			*Amomum*	1
3			*Etlingera*	2
4			*Hornstedtia*	1
5			*Meistera*	1
6			*Wurfbainia*	1
7	Zingiberoideae	Hedychieae	*Hedychium*	1
8		Zingibereae	*Curcuma*	1
9			*Zingiber*	1
			Total:	**11**

The genera *Alpinia* and *Etlingera* constitute the highest number of collected species with 2 species for each genus and the rest of the genera, such as *Amomum*, *Hornstedtia*, *Meistera*, *Wurfbainia*, *Hedychium*, *Curcuma*, and *Zingiber* are represented with only one species. Based on the list of Philippine Zingiberaceae by Pelser et al. (2011 onwards), the collected species constitute *ca.* 8% of the total number of Philippine Zingiberaceae. Eight species have been recorded in Mt. Musuan, while 5 species were collected in CMU view deck (*A. dealbatum* and *H. conoidea* occur in two sites) (**Table 2**). The collected species

are few, but considering the presence of five Philippine endemic and noteworthy species out of 11 collected species, this paper is significant and warrants further studies. It is also interesting that eventhough Mt. Musuan has a secondary forest, these species are already in the sites and await discovery. This is because members of this family are neglected since vegetative morphologies of the species closely resemble each other and local people and researchers often mistakenly treat them as the same species.

Table 2. Occurrence of Zingiberaceae in Mt. Musuan and CMU View Deck, Bukidnon.

No.	Species	Distribution	
		Mt. Musuan (main mountain)	View Deck (base of Mt. Musuan in Kibulawan)
1	*Alpinia haenkei* C.Presl.	/	
2	*Alpinia purpurata* (Vieill.) K.Schum.	/	
3	*Amomum dealbatum* Roxb.	/	/
4	*Curcuma zedoaria* (Christm.) Roscoe	/	
5	*Etlingera elatior* (Jack) R.M.Sm.		/
6	*Etlingera philippinensis* (Ridl.) R.M.Sm.	/	
7	*Hedychium coronarium* Koenig		/
8	*Hornstedtia conoidea* Ridl.	/	/
9	*Meistera muricarpa* (Elmer) Škorničk. & M.F.Newman	/	
10	*Wurfbainia elegans* (Ridl.) Škorničk. & A.D.Poulsen		/
11	*Zingiber zerumbet* (L.) Smith	/	

According to Smith et al. (1988), the classification of Zingiberaceae had been recognized widely based on morphological characters and molecular phylogeny. As for this study, morphological characters were used for plant identification and species delineation. Variation on the inflorescence of each species is important, since it is the main characteristic in distinguishing specific genera. Based on their reproductive parts, inflorescence and infructescence emerge terminally on leafy shoots, such as *A. haenkei*, *A. purpurata*, and *H. coronarium* or arise from the rhizome, such as *A. dealbatum*, *C. zedoaria*, *E. elatior*, *E. philippinensis*, *H. conoidea*, *M. muricarpa*, *W. elegans*, and *Z. zerumbet*.

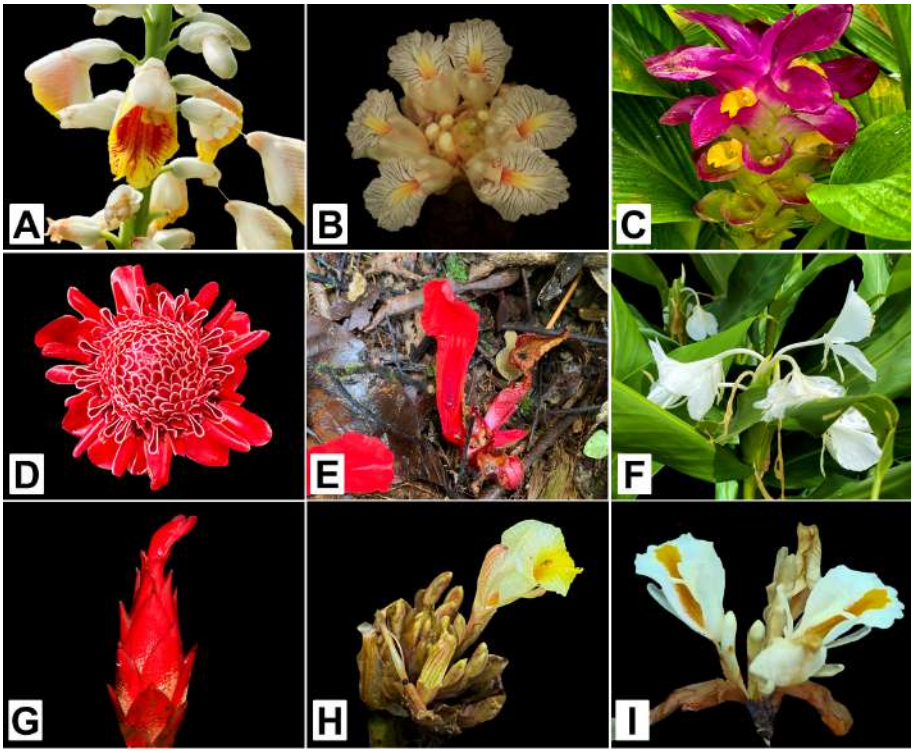

Figure 2. Representative ginger species in Mt. Musuan and its vicinity in Bukidnon, Southern Philippines. **A)** *Alpinia haenkei* C.Presl., **B)** *Amomum dealbatum* Roxb., **C)** *Curcuma zedoaria* (Christm.) Roscoe, **D)** *Etlingera elatior* (Jack) R.M.Sm., **E)** *E. philippinensis* (Ridl.) R.M.Sm., **F)** *Hedychium coronarium* Koenig, **G)** *Hornstedtia conoidea* Ridl., **H)** *Meistera muricarpa* (Elmer) Škorničk. & M.F.Newman, **I)** *Wurfbainia elegans* (Ridl.) Škorničk. & A.D.Poulsen. *Photographs by N.P.Mendez.*

Assessment of Conservation Status and Endemism of the Species

Among the 11 collected species, no species of gingers were considered threatened; however, five of these are endemic to the Philippines, *viz.*, *A. haenkei*, *E. philippinensis*, *H. conoidea*, *M. muricarpa*, and *W. elegans*, while the rest of the species are introduced to the Philippines (Table 3). These five Philippine endemic species are rare in Mt. Musuan, but most of these, such as *A. haenkei*, *E. philippinensis*, *H. conoidea*, and *M. muricarpa* were frequently collected by the authors during the botanical expeditions in other Mindanao mountain ecosystems. It is also noted *E. elatior* and *Z. zerumbet* are naturalized in the Philippines (Steiner, 1959), *A. purpurata* and *C. zedoaria* are known for cultivation and not naturalized (Pelser et al., 2011 onwards), and *H. coronarium* is an invasive species (de Castro et al. 2016; CABI 2022). There were no

threatened species recorded in the area compared to other mountain ecosystems.

The *C. zedoaria* is a species known as "luyang dilaw" aside from its sister species – *C. longa* L. by the local people in Mindanao and is produced to make a lot of products, such as tea, condiments and medicine. This species is planted outside the entrance of CMU view deck in addition to the garden decoration. The *A. purpurata* and *E. elatior* are usually propagated in Bukidnon because of their giant habits and very colourful inflorescences making the plant lovers cultivate them and their inflorescences were usually used for special occasions in church for decorative purposes. Upon the collection of the specimens, the former has only sterile population. Because of its variegated leaves, Z. zerumbet has also paid importance in terms of cultivation to the local people. This plant can be seen at the entrance of Mt. Musuan, and is usually seen outside houses nearby the study sites.

Table 3. Assessment and Ecological Status of Zingiberaceae in Mt. Musuan and CMU View Deck, Bukidnon

No.	Species	Assessment of Ecological Status
1	*Alpinia haenkei*	Philippine Endemic
2	*Alpinia purpurata*	Introduced
3	*Amomum dealbatum*	Introduced
4	*Curcuma zedoaria*	Introduced; Known for Cultivation
5	*Etlingera elatior*	Introduced, Known for Cultivation
6	*Etlingera philippinensis*	Philippine Endemic
7	*Hedychium coronarium*	Introduced; Invasive Species
8	*Hornstedtia conoidea*	Philippine Endemic
9	*Meistera muricarpa*	Philippine Endemic
10	*Wurfbainia elegans*	Philippine Endemic
11	*Zingiber zerumbet*	Introduced; Known for Cultivation

In Mt. Hamiguitan, 11 endemic species of gingers were collected including the *Etlingera* sp. which was later on identified as *Etlingera pilosa* A.D.Poulsen & Docot (Acero et al., 2019). In Marilog Forest Reserve, Southern Philippines, only one species (*Hedychium philippinense* K.Schum.) was recorded as threatened species under the Endangered category and 14 endemic species were recorded (Acma et al., 2020). In Cinchona Forest Reserve at the foot of Mt. Kitanglad, *H. philippinense* was also recorded as the only threatened species and nine species of gingers were recorded as endemic to the Philippines (Jayme et al., 2020). With the 11 recorded ginger species in Mt. Musuan, it is lower than the studies of Acero et al. (2018) and Acma et al. (2020), but has the same number of species collected by Jayme et al. (2020).

Conclusions and Recommendations

A total of 11 species of gingers belonging to nine genera in three tribes and two subfamilies were recorded from Mt. Musuan and its vicinity in Bukidnon, Southern Philippines. The collected species constitute *ca.* 8% of the total number of Philippine Zingiberaceae and 5% of the collected species are endemic to the Philippines. *A. haenkei*, *A. purpurata*, *C. zedoaria*, *E. philippinensis*, *H. conoidea*, *M. muricarpa*, and *Z. zerumbet*. were recorded in Mt. Musuan, while *A. dealbatum*, *E. elatior*, *H. coronarium*, *H. conoidea*, and *W. elegans* were collected from CMU View Deck. Of the collected species, five of these are endemic to the Philippines, while the other six species are introduced. These species are mostly associated with ferns, understorey flowering plants, and Dipterocarpaceae species.

It is recommended that an urgent call for *in situ* conservation efforts to be done by the concerned authorities of Central Mindanao University to help preserve and protect these species since 3.52% of these species are endemics in the Philippines. Also, as ecotourism sites, there is a need to regulate receiving visitors in these sites, and if possible, tree planting activities be considered as an activity. Botanists from CMU should also be consulted prior to road widening in the area, since this could threaten the species as most of them are found along the trail.

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