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Research Article

Diversity of gingers at Serudong, Sabah, Malaysia

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ABSTRACT

The species richness and abundance of the Zingiberaceae (hereafter gingers) were studied in five study plots in Serudong and in one study plot in an adjacent area. The study plots were in undisturbed upland kerangas forest (mossy kerangas forest), one in an undisturbed lower montane-kerangas forest, one in disturbed upland mixed dipterocarp forest, and three in upland mixed dipterocarp-kerangas forest (disturbed, partially disturbed and undisturbed, respectively). Thirty-nine species were documented from the general area; eight of which were found outside the plots. Eighty-one percents of the species were recorded from the disturbed forest plots. None of the species were recorded from the undisturbed upland kerangas and lower montane-kerangas forest plots. Species richness averaged 11 species per hectare. The index of diversity of gingers for the study area was estimated to be 2.0 (Shannon diversity index, *H*') and it was highest in the disturbed upland mixed dipterocarp forest plot. At the scale of this study, the diversity of gingers in Serudong is found to be lower than that of many other forest reserves in Sabah. The most novel collection was *Geostachys*, a genus that was documented in Sabah only recently. This finding was the second for a species of this genus in Sabah.

Keywords: Gingers, species composition, Borneo

INTRODUCTION

The diversity of gingers in Serudong has not been well documented. Therefore, in 2006, a team from the Sabah Forestry Department carried out an expedition to study the density and composition of these plants in this area. The collected information can be used to assess the importance of Serudong as an *in-situ* conservation area for gingers in Sabah. The results are reported in this paper.

METHODS

Study Site

Serudong is a 123,643 ha forest management unit (FMU25) situated in southern Sabah on the border to Kalimantan (4°12 – 33'N, 117°8 – 32'E; Fig. 1). The elevation is 450 – 1,300 m above sea level but only a few hills rise above 1,000 m (Sabah Forestry Department, 2005). The daily temperature fluctuates from 21°C to 32°C. The annual rainfall is 2,500 – 3,500 mm. The area is characterized by the Kapilit geological formation and Lokan and Crocker are the main soil associations; others are Maliau, Labau, Kalabakan, Serudong and Gomantong associations. Its main soil unit is orthic acrisol, which is sandy and less fertile.

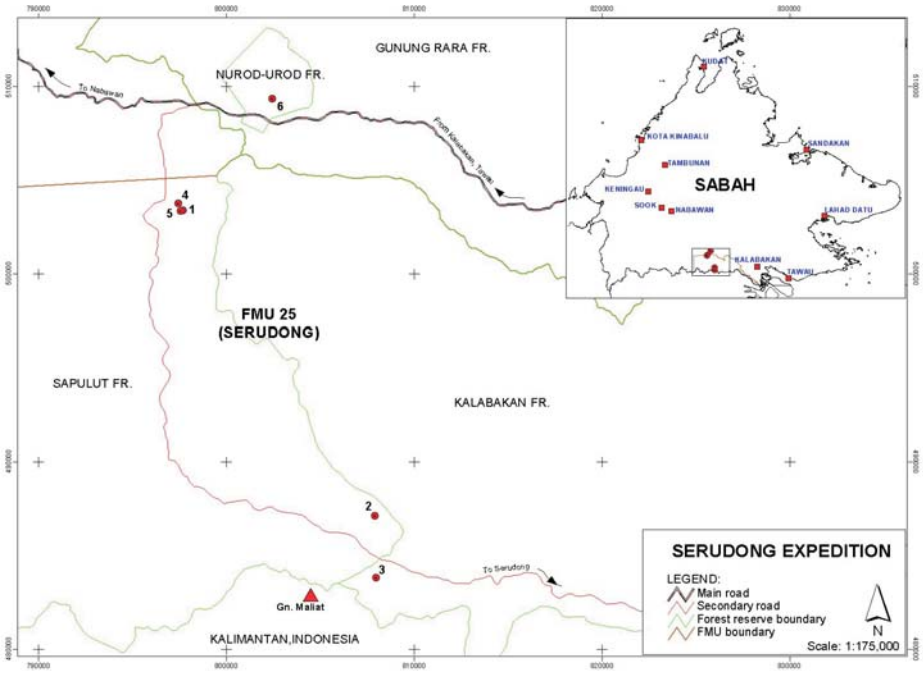

Figure 1: Location of Serudong (FMU25) in Sabah (insert picture) and locations of the study plots in FMU (plot 1–5). The control plot (plot 6) was established in Nurod-Urod Forest

The natural vegetation of the area is composed of upland mixed dipterocarp-kerangas (59.1%); lower montane-kerangas (17.8); lowland mixed dipterocarp-kerangas (7.1); lowland mixed dipterocarp (6.6); upland mixed dipterocarp (4.9); upland kerangas (4.4; mossy kerangas forest *sensu* Fox, 1972); and lowland kerangas forests (0.1). A large portion of the forest is in secondary and logged-over conditions.

Sampling Method

Five study plots (1–5) were established in four of the major forest types in Serudong (Table 1). The locations of the plots were pre-identified on a satellite image of the study area and were visited on the ground. One control plot (Plot 6) was established in Nurod Urod Forest Reserve, a forest reserve in adjacent area to Serudong.

In the plots, gingers were identified and counted. Relative density of the species was calculated as sum of density of the species divided by sum of density of all species and multiplied by 100. From these data, the diversity of the gingers was estimated using PCORD® (McCune & Mefford, 1999; version 4.14). The same software was used to run a cluster analysis to find out the similarity of composition of gingers between the studied forest types (distance measure: Sorensen (Bray-Curtis); linkage: group average). The gingers were also qualitatively surveyed along the trail to the peak of Gunung Maliat (1,300 m), which is situated on the international boundary that separates Sabah and Kalimantan, Indonesia. Voucher specimens were kept at Sandakan Herbarium (SAN).

Table 1: The five plots established at Serudong (plot 1–5) and the one from Nurod Urod (plot 6) and their characteristics

Plot	Forest Type	Disturbance	Size (m^2)	Elevation (m)
1	Upland kerangas	Undisturbed	4 × 20	770
2	Lower montane-kerangas	Undisturbed	4 × 50	1300
3	Upland mixed dipterocarp	Disturbed	4 × 190	860
4	Upland mixed dipterocarp-kerangas	Disturbed	4 × 300	700
5	Upland mixed dipterocarp-kerangas	Partially disturbed	4 × 400	720
6	Upland mixed dipterocarp-kerangas	Undisturbed	4 × 500	760

RESULTS

No gingers were recorded from the undisturbed upland kerangas forest (Plot 1) and undisturbed lower montane-kerangas forest plots (Plot 2). The remaining plots harboured 31 species (Table 2). Eight additional species were found outside the plots (*Burbidgea schizocheila* Hackett, *Elettariopsis kerbyi* R.M. Sm., *Etlingera rubromarginata* A.D. Poulsen & Mood, *Etlingera brachychila* var. *vinosa* A.D. Poulsen, *Geocharis fursiformis* var. *borneensis* R.M. Sm., *Hedychium cylindricum* Ridl., *Hedychium* sp., and *Zingiber argenteum* Theilade & Mood). Of these 39 species, eight taxa were identified only to the genus due to the lack of flowers for a thorough identification.

Species richness averaged 11 species per hectare (ranged 7–17 per plot). The index of diversity and species evenness of gingers and species evenness in the area were estimated to be 2.0 (Shannon diversity index, H') and 0.9, respectively (Table 3). Relative density averaged 3(±6) stems per hectare. Index of diversity, species count, relative density and species evenness were highest in the disturbed forest plots. In terms of species composition and relative density, the cluster analysis showed that Plots 3 and 4 were inseparable from each other and were distinctively dissimilar (100%) from Plots 5 and 6. Plots 5 and 6, on the other hand, were only 57% similar.

The most interesting collection was that of *Geostachys*, a genus that was found occurring in Sabah only recently at Maliau Basin (see Lim & Lau, 2006). Serudong is thus a new locality for its occurrence. The species was represented by 22 clumps in the partially disturbed upland mixed dipterocarp-kerangas forest plot (Plot 5). This species has a potential as an ornamental; the leaves were dark green with burgundy underneath and the stem was dark green with reddish base. The old and dried inflorescence was found with old floral bracts congested at its top and the old fruits appear to be oblong; this species is distinct from that described from Maliau Basin.

DISCUSSION

At the scale of this study, the diversity of gingers in Serudong is found to be lower than that of many other forest reserves in Sabah. There are about 168 species of gingers in Sabah (see: Gobilik & Yusoff, 2005; Gobilik *et al*., 2005a; Poulsen, 2006; Julius *et al*., 2007), but only 23% are found at Serudong. The number of species in this area can be ranked as lower than that of Mt. Kinabalu (Gobilik & Yusoff, 2005), Imbak Valley (Gobilik *et al*.,

Table 2: List, relative mean density and evenness of ginger species in the study plots

No.	Species	Mean (±SD)	Evenness
1	*Alpinia ligulata* K. Schum.	5.9 (6.9)	1.0
2	*Alpinia nieuwenhuizii* Val.	3.2 (6.5)	0.0
3	*Amomum borealiborneense* I.M. Turner	1.6 (1.9)	0.9
4	*Amomum coriaceum* R.M. Sm.	4.3 (8.6)	0.0
5	*Amomum dimorphum* M. Newman	2.2 (2.9)	0.9
6	*Amomum oliganthum* K. Schum.	1.4 (1.7)	0.9
7	*Amomum* sp.	3.6 (7.1)	0.0
8	*Amomum testaceum* Ridl.	5.6 (11.2)	0.0
9	*Amomum uliginosum* Koenig	11.7 (14.8)	0.9
10	*Boesenbergia variegata* R.M. Sm.	1.2 (2.4)	0.0
11	*Elettaria surculosa* (K. Schum.) Burtt & R.M. Sm.	3.6 (5.8)	0.6
12	*Etlingera albolutea* A.D. Poulsen	0.6 (1.2)	0.0
13	*Etlingera baculutea* A.D. Poulsen	0.5 (1.0)	0.0
14	*Etlingera brevilabrum* (Val.) R.M. Sm.	2.7 (4.7)	0.5
15	*Etlingera inundata* Sakai & Nagam.	5.0 (3.6)	1.0
16	*Etlingera velutina* (Ridl.) R.M. Sm.	1.2 (2.4)	0.0
17	*Geostachys* sp.	11.2 (22.5)	0.0
18	*Globba pendula* Roxb.	1.2 (2.4)	0.0
19	*Globba propinqua* Ridl.	0.3 (0.6)	0.0
20	*Hornstedtia reticulata* K. Schum.	0.5 (1.0)	0.0
21	*Hornstedtia* sp.	0.6 (1.2)	0.0
22	*Plagiostachys breviramosa* Cowley	1.2 (2.4)	0.0
23	*Plagiostachys* aff. *roseiflora* A. Julius & A. Takano	0.3 (0.6)	0.0
24	*Plagiostachys oblanceolata* J. Gobilik & A. Lamb	8.1 (10.6)	0.9
25	*Plagiostachys* sp. a	1.5 (2.9)	0.0
26	*Plagiostachys* sp. b	3.1 (6.1)	0.0
27	*Plagiostachys strobilifera* (Bak.) Ridl.	6.3 (9.7)	0.7
28	*Zingiber pseudopungens* R.M. Sm.	2.9 (4.5)	0.7
29	*Zingiber* sp. a	1.1 (1.3)	1.0
30	*Zingiber* sp. b	0.6 (1.2)	0.0
31	*Zingiber viridiflavum* Theilade & Mood	0.3 (0.6)	0.0
Averages:		3.0 (4.9)	0.3

Table 3: Relative mean density, species count (S), evenness (E) and diversity index of gingers in the study plots (H = Shannon's diversity index; D = Simpson's diversity index)

Plot	Mean (±SD)	S	E	H	D	Forest Condition
3	2.4 (3.5)	17	0.9	2.5	0.9	Disturbed
4	3.2 (4.9)	12	0.9	2.4	0.9	Disturbed
5	3.2 (9.2)	8	0.7	1.5	0.7	Partially disturbed
6	3.2 (7.8)	7	0.9	1.7	0.8	Undisturbed
Averages:	3.0 (6.4)	11	0.9	2.0	0.8	

2005b), Tabin Wildlife Reserve (Gobilik, 2002), Crocker Range Park (Gobilik & Yusoff, 2005), Danum Valley (Magintan, 2000), Maliau Basin, and Tawau Hills Park (Gobilik, 2005; unpublished expedition data). Nevertheless, Serudong harbours more gingers than the Mt. Trus Madi area (Gobilik & Yusoff, 2005), another area in Sabah where the upland mixed dipterocarp forest type is also prominent.

The low diversity of gingers in Serudong can be associated with many factors. The most important could be the distribution of kerangas (heath) soil, degrees of forest disturbance, and altitudes in the study area. Kerangas forest is known to be infertile (Newbery, 1991), and this forest will not support many ginger species, which are generally known to grow well only on moist and high-organic-content soils (Larsen *et al*., 1999). The low species count in the undisturbed upland mixed dipterocarp-kerangas forest plots indicates the adverse effect of kerangas soil to recruitment of gingers. Most of the species are even occurring at a very low frequency and abundance as one can interpret from the very low evenness of the species (see Table 2). Gingers are generally non-specialist regarding substrate (Theilade, 1998) especially in kerangas forest, perhaps with the exception of *Etlingera dictyota* (Poulsen, 2006).

Forest destruction reduces plant diversity (Slik *et al*., 2002), but to a certain degree, it could cause the contrary (Connell, 1978). In Serudong, the latter appears to be case because the disturbed forest plots harbour more species than the undisturbed forest plots (Table 3). Thus it could be that in the forest where the soil is infertile such as in kerangas forest, logging would instead increase soil fertility as well as ginger diversity. It is quite logic to assume that nutrients from the rotting tree branches and stumps are recycled into the soil and are consumed by the gingers. The gingers would then have more energy to reproduce as one can interpret from their slightly higher Simpson's diversity index from the disturbed forest plots (Table 3; Simpson's diversity index is reported to be positively dependent on species' abundance – see Magurran, 1988). This scenario, however, does not imply that the disturbed kerangas forest could facilitate a recruitment of gingers beyond that of forests of fertile soils.

Although some gingers are confined in montane forests (Beaman & Beaman, 1998), the richness of ginger species decreases with increasing altitude (Gobilik & Yusoff, 2005). Hence the low diversity of gingers in this study can be associated with the fact that the study plots (all) were established in upland forest, which is occurring just above the so-called lowland forest, a forest where gingers are usually abundant (Gobilik & Yusoff, 2005). As evidence, none of the species were found in the undisturbed lower montane-kerangas forest plot (1,300 m) or along the trail to the peak of the Gunung Maliat (1,000 – 1,300 m). Moreover, gingers have not yet been reported to inhabit mossy forest (>2,300 m elevation), even on large mountains such as Mt. Kinabalu and Mt. Trus Madi (Gobilik & Yusoff, 2005). Therefore, they are not expected to inhabit upland kerangas forest, which is a mossy forest *sensu* Fox (1972). In Serudong, mossy forest took event at lower altitude (700 m in this study) due to 'Massenerhebung effect', a reduction in the lower altitudinal limits of vegetation zones on isolated hills of infertile soils, a common phenomenon which occurs in south-eastern of Sabah (Fox, 1972).

Light and precipitation are the other two factors for the higher density and species richness of gingers in the disturbed forest. This is because many gingers are growing well only in open, wet and humid conditions

(Larsen *et al*., 1999; Poulsen, 2006). In other word, the previous logging activities in the study area had opened the forest canopy and facilitated more light to reach the gingers on the ground, and in Serudong, where the precipitation is relatively high (2,500–3,500 mm), water does not limit their survival even after they were being exposed to heavy sunlight by the logging activities. On the other hand, they generate more energy to reproduce, because they receive enough light, water, and nutrient (from the rotting tree stems and branches) to carry out a productive photosynthesis. In other words, the open canopy, high precipitation, and nutrient from the rotting wood debris left by the logging are at least compensating the adverse effect of kerangas soil on ginger's recruitment in the study area.

The present results also underline the importance of gingers as indicators of forest disturbance. The composition of gingers reflects the disturbance level of the forest very well as one can interpret from the Cluster Analysis's result. Nevertheless, none of the species are confined in either forest condition. Similar results had also been reported from Tabin Wildlife Reserve (Gobilik, 2002).

As a summary, 62% of the species in Serudong are widespread gingers in Sabah, 13% are locally abundant at several districts and 5% are locally rare. Of the remaining 21% non-identified species, only the species of *Geostachys* may be confined to this area. In addition, this species could be new species since it is distinct from that was described from Maliau Basin. If so, at the scale of this study, the importance of Serudong as an *in-situ* conservation area for gingers can be highlighted only by the occurrence of this species and the 5% locally rare species of the area. Many more special gingers may, however, be found at this area in the future if intensive inventories were to be carried out.

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