Report

Zingiberaceae and Costaceae of the Trus Madi Range

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ABSTRACT. This paper reports the species composition of Zingiberaceae and Costaceae in the Trus Madi Range. The gingers were sampled between the elevations of 1,400 m a.s.l and 2,649 m a.s.l, en route from the former base camp of the Forestry Department to Mt. Trus Madi peak and along six 200-m-long line transects. Twenty-one species of Zingiberaceae and two species of Costaceae were recorded. All species were documented below the elevation of 1,700 m. The inclusion of these gingers brings the Zingiberaceae-Costaceae herbarium record of the Trus Madi area to 25 species. Three species endemic to the Crocker Range and Mt. Kinabalu were recorded in the study area, namely, *Amomum kinabaluense, Amomum sceletescens* and *Zingiber kelabitianum.* Besides being poorly populated by gingers, the study area is highly similar in composition of gingers to three sites in the Crocker Range. If such similarity is consistent for other areas in the Crocker Range, the Trus Madi Range could serve as another conservation area for montane gingers in Sabah.

INTRODUCTION

Zingiberaceae, or gingers, are rhizomatous herbs with secretory cells that produce aromatic oils. They form a pseudostem, *i.e.*, a stem comprising many layers of leaf sheaths. A few species, however, form a short herbaceous stem that is enveloped by the leaf sheaths. Costaceae is the sister family to Zingiberaceae; it is non-aromatic and forms a real but still herbaceous stem. The species in these plant families are important as ornamental plants (Ibrahim, 1990), vegetables, and as ingredients in traditional medicine (Ibrahim, 1995; Theilade, 1998; Larsen *et al.*, 1999), or contain a remedy for rheumatism (Norliza, 1998) and anti-bactericidal substances (Swerdlow, 2000). Gingers are also food plants of animals and insects in the forest.

Even though known to be useful, Zingiberaceae and Costaceae in Sabah are not widely studied. The previous studies have been devoted mainly to the taxonomy of these plants (e.g., Smith, 1985, 1986, 1987, 1988; Theilade, 1997, 1999). Only a few studies are about other aspects such as ethnobotany and chemistry (e.g., Theilade, 1998), and ecology (e.g., Magintan, 2000; Gobilik, 2002). Although 156 species have already been described (Table 1), the diversity of these plants remains largely unknown in Sabah (Mood, 1996). The worrying trend in Sabah, however, is the rapid loss of forest to other land uses, which is threatening the biodiversity, including the gingers.

Keywords: Gingers, distribution, Mt. Trus Madi, Borneo.

Table 1. The number of Zingiberaceae and Costaceae species in Borneo

	Number of Species											
Genera	*Borneo	Sarawak	Sabah	Brunei	Mt. Kinabalu	Mt. Mulu	Tabin Wildlife Reserve	Lambir Hill	Crocker Range Park	Danum VCA	Tawau Hill Parks	Trus Madi
Amomum	41	26	27	22	10	4	6	10	7	8	4	4
Zingiber	29	14	18	6	3	1	5	2	5	3	4	4
Etlingera	26	19	29	9	10	4	10	8	8	5	6	5
Boesenbergia	23	17	21	19	3	13	3	6	3	2	1	-
Alpinia	17	12	15	10	9	6	4	2	4	1	2	2
Hornstedtia	12	7	10	7	4	2	1	3	1	1	1	2
Globba	11	11	6	5	5	4	2	1	4	2	3	3
Elettaria	8	8	3	4	-	4	1	4	-	1	1	-
Plagiostachys	9	5	11	9	4	2	7	4	2	9	1	-
Burbidgea	5	5	3	6	2	4	-	-	2	-	1	1
Scaphochlamys	5	5	-	5	-	-	-	-	-	-	1	-
Costus	5	3	4	6	5	2	3	2	2	2	2	2
Elettariopsis	3	1	4	6	-	1	2	3	1	2	-	-
Haplochorema	3	4	-	-	-	1	-	-	-	-	-	-
Hedychium	4	3	4	2	2	1	1	-	3	-	1	2
Geocharis	2	1	1	-	-	-	1	-	-	-	1	-
Geostachys	1	1	-	-	1	1	-	-	-	-	-	-
Tamijia	1	1	-	-	-	-	-	1	-	-	-	-
Camptandra	1	1	-	-	-	-	-	-	-	-	-	-
Genera: Species	19:206	19:144	14:156	14:116	12:58	15:50	13:46	12:46	12:42	11:36	14:29	9:25
Species (%) (Site/Borneo)	100	70	74	55	27	24	22	22	20	17	14	12
Reference (see Appendix 1)	1-31	10,11,13-21, 23, 24	1,2,5-7,19-31, Mood (1996)	2-5	1,19-27	18-21, 23, 24	Gobilik (2002)	13-17, 19-21, 23, 24	19-27	9	6	This Study

*Based on collection from Sabah, Sarawak and Brunei.

A large portion of Sabah's lowland forests has been repeatedly logged. The practice has caused a vast portion of the forest to be in an unproductive and uneconomic condition for re-logging. Consequently, logging has been extended to montane forests, especially on the Trus Madi Range; more than half of the range has been logged. As a result, only a steep area towards the peak of Mt. Trus Madi remains as primary forest. From a biodiversity perspective, this remaining undisturbed habitat may be unable to sustain the unique flora and fauna in the range.

A proper report about the composition of Zingiberaceae and Costaceae in the Trus Madi range is not yet available. The early study of gingers in this range was based only on specimens of *Globba* (*Globba atrosanguinea, Globba propinqua* and *Globba tricolor* var. *gibbsiae*) collected from that area in the 1970s (Smith, 1988). Subsequent studies were carried out in 1986 and 1996. Specimens were deposited in the Sandakan herbarium (SAN).

In this paper, we report a preliminary checklist and a general account on spatial distribution of gingers in the Trus Madi Range based on a survey conducted in 2001.

METHODS

Study site

The survey was carried out at the Trusmadi Forest Reserve (TFR), Trus Madi Range, (N5°15' and N5°45'; E116°15' and E116°45') between the elevations of 1,400 m a.s.l and 2,649 m a.s.l (the peak of Mt. Trus Madi). TFR is a montane forest area of mainly logged-over forest except the area above the elevation of roughly 1,700 m a.s.l, which constitutes a primary forest. The general description of the forest in the study area is as follows. Dipterocarp forests dominate the lowland portion of the Range, but towards the higher elevation, the vegetation changes to oak/conifer and mossy forests. Gymnosperms such as *Agathis* and *Phyllocladus* species are common between 1,400 m a.s.l and 1,700 m a.s.l, but obviously, the recent logging activities have damaged a large number of its individuals. The area above 1,800 m a.s.l elevation is basically very wet, the trees are contorted, and the vegetation is of mossy forests with Ericaceae as their dominant flora.

The temperature at the study area is below 18°C. Precipitation was not measured during the study, but in general, the Trus Madi area receive1,500 to 2,000 mm rainfall annually (Sabah Forestry Department internal record). The soils and geology of the Trus Madi Range belong to the Trusmadi Association, the parent materials of which differ from the Crocker Association (Bower *et al.*, 1975). The latter association has flysch-type sandstone and shale from the Oligocene age. The Trusmadi Association occurs over 1,200 m a.s.l, whereas the Crocker Association has never exceeded 1,200 m a.s.l. Thereby, a few areas in the Crocker Range such as Mt. Alab (1,965 m a.s.l.) have the Trusmadi Association. In general, the mineralogy and chemistry of both ranges are similar (Bower *et al.*, 1975).

Documentation of gingers

In the present survey the gingers were recorded along a 5-km-long old logging road. This road connects the former base camp of the Forestry Department (N5°35.130'; E116°29.398') with the junction of the route to the peak of Mt. Trus Madi. The survey was then extended along the route to the peak of Mt. Trus Madi to cover the undisturbed forest of the study area.

In addition, gingers were also recorded along six 200-m-long line transects. The gingers were recorded within 5 m at both sides of the line. The line transects were laid out at 400 m intervals perpendicularly to the logging road (penetrating the roadside forested areas). The first line was near the base camp. All transects were established within the logged forest of below 1,700 m a.s.l. The sampling lines cut across different degree of logging disturbances from less severe, including a partially disturbed forest, to severe. Here, partially disturbed forest is referred to as a patch of forest in the logged forest matrix where the logging had no direct impact. Four transects were laid going upstream, and two on the ridges. Sampling was emphasized along the stream banks because gingers are usually abundant at such habitats. Results of the previous studies on gingers in Borneo also showed this trend (Fig. 1).

For each species, its habitat was assessed roughly and the elevation was recorded. The data were compared with the composition of gingers at different sites in Sabah, Sarawak and Brunei. The species were identified based on the published taxonomic keys and descriptions of the gingers of Borneo (Smith, 1985, 1986, 1987, 1988, 1989; Theilade, 1997, 1999).

RESULTS

Including the records in SAN (Sandakan) Herbarium, the study area harboured 25 species of gingers, and among these 21 species were found during the present field survey (Table 2). Eight genera were found in the Zingiberaceae.

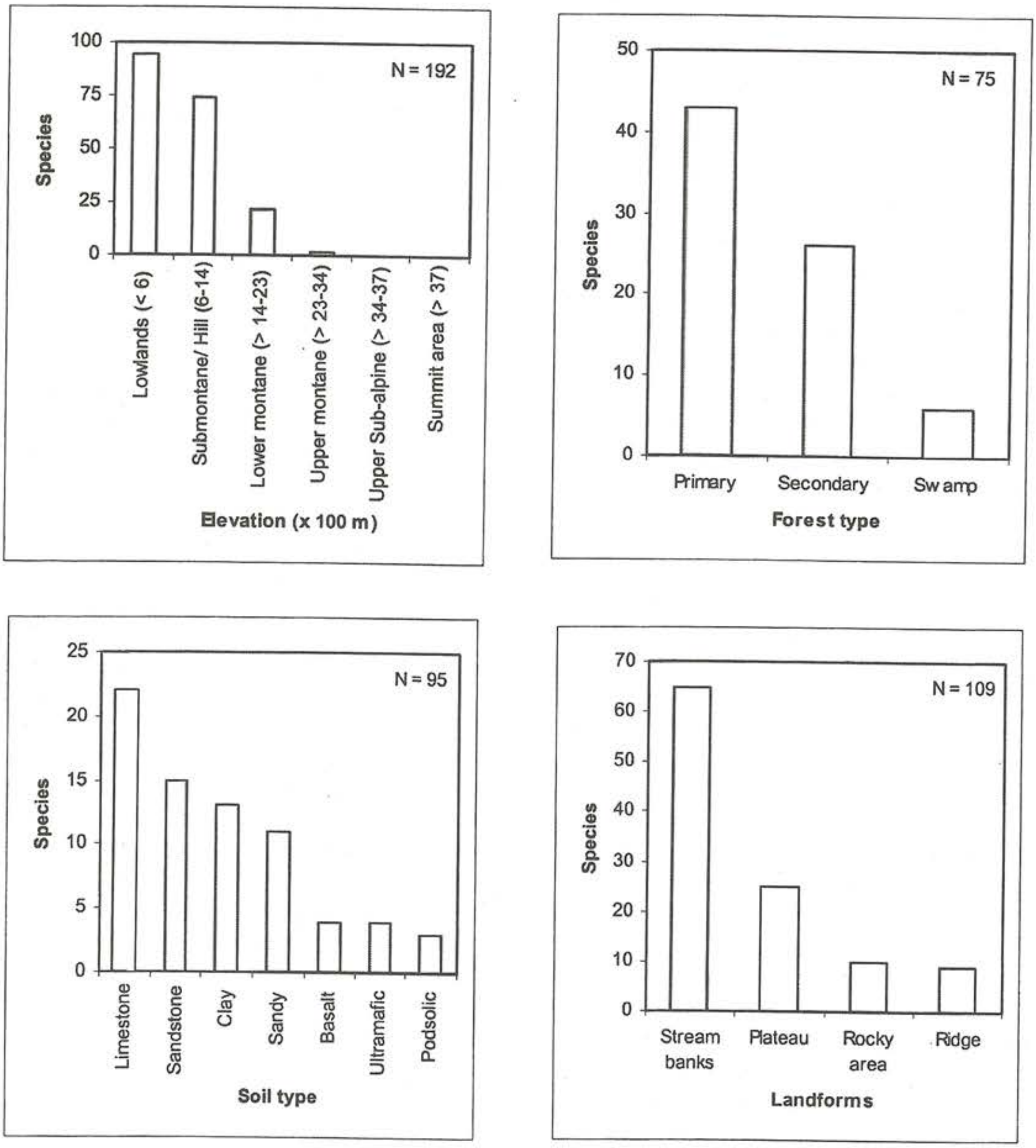

Fig. 1. The number of Zingiberaceae and Costaceae species in Borneo at different elevations, forest types, soil types and landforms. (Source: see Appendix 1; 211 species were studied; N = number of sample.)

The genus *Etlingera* had the highest number of species (five), followed by *Amomum* and *Zingiber* with four species each. In fact Bornean gingers are mainly represented by these genera (see Table 1). This number made up 16% and 12% of the Zingiberaceae-Costaceae in Sabah and Borneo, respectively.

Three interesting species were recorded from the study area. Two of the species were *Amomum kinabaluense* and *Amomum sceletescens*. Previously, these species were believed to be endemic to Mt. Kinabalu and the Crocker Range (Smith, 1987, 1990). Another species was *Zingiber kelabitianum*, a species that was also believed to be restricted to the Kelabit Highlands in Sarawak (Theilade & Christensen, 1998). The occurrence of *Z. kelabitianum* in the study area was the second record of the species in Sabah after it had been collected in the Crocker Range. The study area itself, however, did not yield an endemic species.

The occurrence of ginger species or individuals of the species in the study area was generally not frequent. Only two to four species each had less than three individuals or only two species each had five to seven individuals along the 200 m transects. In the primary forest, the gingers were found with only one or sometimes up to three individuals. In general, only four species (*Amomum sceletescens*, *A. kinabaluense*, *A.* sp. A, and *Burbidgea schizocheila*) were recorded in the primary forest. In the logged forest, the gingers were more frequent than in the primary forest. However, where a high density of pioneer species and a thick net of woody vines were found, only a few gingers could be found growing within the 200 m transects. At certain places within this disturbed habitat, however, there was a species found growing abundantly (e.g., *Etlingera fimbriobracteata*). This species dominated the area where a tree had been felled or at certain locations along the logging road. In the partially disturbed forest, three to four species could be found sharing the area; a few of these species are primary forest species.

In this survey, the species that were found common along the logging road were also the species that were common and abundant under similar conditions in other logged forests in Sabah (e.g., *Etlingera fimbriobracteata* and *Costus speciosus*). In contrast, however, in the Trus Madi area the species were not reproducing vigorously and were not widely distributed (locally abundant) than what was observed, for example, along the logging roads to the Danum Valley Conservation Area or in the Tabin Wildlife Reserve (personal observations).

The compositions of gingers along the line transects and at the side of the logging road were also closely similar. Twenty-one species were recorded in the six 200 m line transects of which 16 species were found at different locations on the logging roadside. Unfortunately, statistical analysis to support this similarity was not carried out in this study because it was inappropriate to do so when the sampling intensities for these habitats were not equivalent (5 km long logging road versus 1.2 km (6 × 200 m) long line transect).

As expected, the number of ginger species decreased with increasing elevation (Fig. 2). The gingers were relatively abundant up to 1,000 m a.s.l before they became scarce when reaching 1,500 m a.s.l. This trend was analogous to the altitudinal distribution of gingers elsewhere in Borneo (Fig. 1). None of the species in this study was recorded after 1,700 m a.s.l even though on Mt. Kinabalu, gingers have been reported to occur up to 2,300 m elevation (see montane species in Appendix 1). Notable examples were the *Alpinia havilandii*, *Amomum longipendunculatum*, *A. kinabaluense*, *A. sceletescens*, and *Burbidgea stenantha*.

Table 2. Zingiberaceae and Costaceae species from the study area in Trusmadi Range and notes on its distribution in Sabah.

Zingiberaceae

Alpinia

A. nieuwenhuizii ([1]Gobilik 906) ([2]SAN 109424) (widespread)
A. havilandii (SAN 125571)
A. cf. *ligulata* (SAN 109424) (identification doubted; probably *A. nieuwenhuizii*)

Amomum

A. sceletescens R.M. Smith (Gobilik 855 & 883) (new record outside of Crocker Range & Mt. Kinabalu)
A. kinabaluense R.M. Smith (Gobilik 912) (new record outside of Crocker Range & Mt. Kinabalu)
A. sp. A (Gobilik 884) (SAN 140805)
A. sp. B (Gobilik 907) (doubted as *A. dictyocoleum*)

Burbidgea

B. schizocheila (Gobilik 825) (widespread in montane areas)
B. sp. A (SAN 122627) (probably *B. schizocheila*)

Etlingera

E. fimbriobracteata (Gobilik 841) (widespread)
E. cf. *muluensis* (Gobilik 826) (identification doubted)
E. aff. *muluensis* (Gobilik 850) (identification doubted)
E. aff. *littoralis* (Gobilik 847, 853, 891& 926) (identification doubted)
E. sp. A (Gobilik 840) (common in Crocker Range)

Globba

G. atrosanguinea (Gobilik 851) (SAN 123970; SAN 113545) ([3]Gardner 64 (E)) (widespread)
G. propinqua (Gobilik 895) (SAN 125534; SAN 123969; SAN 113546) ([3]Sands 4019 (K)) (widespread)
G. tricolor var. *gibbsiea* ([3]Gardner 26 (E)) (widespread in montane areas)

Hornstedtia

H. gracilis (Gobilik 854) (SAN 125604; SAN 140778) (widespread in montane areas)
H. cf. *incana* (Gobilik 932) (SAN 140804)

Hedychium

H. cylindricum (Gobilik 875 & 911) (widespread in montane areas)
H. muluense (SAN 124033) (identification doubted)

Zingiber

Z. coloratum (Gobilik 917) (widespread in montane areas)
Z. kelabitianum I. Theilade & H. Christensen ([2]H.P. Nooteboom 1411)
Z. pseudopungens (Gobilik 892) (widespread in montane areas)
Z. cf. *pseudopungens* (Gobilik 913)

Costaceae

Costus *C. globosus* (widespread)
C. speciosus (widespread)

[1]Collection series in this study; [2]Collection series in SAN (Sandakan) Herbarium; [3]Collection cited by Smith (1988). Detailed authors of the species epithets are presented in Appendix 1.

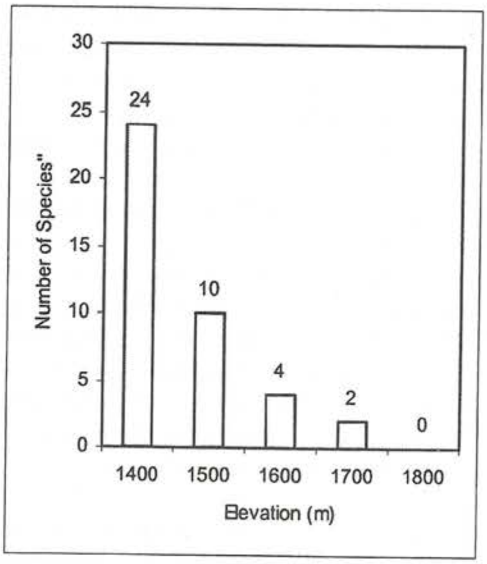

Fig. 2. The number of ginger species from the study area at different elevations.

If the composition of gingers in the study area is compared with that in the other areas in Sabah, the study area and three sites in the Crocker Range, *viz.,* kilometer 39 of the Kota Kinabalu – Tambunan road (800 m a.s.l.), the area near Mt. Alab (1,500 – 1,800 m a.s.l.), and the *Rafflesia* Information Centre area, Tambunan (1,000 – 1,300 m a.s.l.), show a highly similar composition of gingers. The study area and these sites shared the occurrence of montane gingers such as *Alpinia havilandii, A. nieuwenhuizii, Amomum kinabaluense, A. sceletescens, A.* sp. A, *Burbidgea schizocheila, Etlingera* aff. *muluense, E.* aff. *littoralis, Globba atrosanguinea, G. tricolor* var. *gibbsiae, Hornstedtia* cf. *incana, H. gracilis, Hedychium cylindricum,* and *Zingiber pseudopungens.*

DISCUSSION

The diversity of gingers in the studied area is low (see Table 1). A few possible reasons are as follows. It may be due to the sampling intensity because species count and species diversity increase with sampling intensity (Magurran, 1988; Huston, 1995). In this study, the size of the sampled area is small. Thus, only a few species can be expected in our record. Due also to the same reason, the absolute pattern of species equitability is hard to predict in this study. Another reason may be that the study area naturally harbours only a few ginger species. Figure 1 shows that gingers poorly populate montane forests. Only 12% of the 206 ginger species in Borneo inhabit montane areas (> 1,400 m a.s.l) (see Appendix 1). A further reason may be that the disturbances from the previous logging in that area have caused a few ginger species to go extinct. Evidence for this possibility may be that the gingers in the logged forest are not so frequent; in this study, the two to four species found in 200 m distance are far fewer compared with 5-17 species in 100 m distance in Tabin Wildlife Reserve (Gobilik, 2002).

The latter reason, however, contradicts the finding in other studies (e.g., Larsen *et al.* 1999; Poulsen & Lock, 1999; Gobilik, 2002) that many ginger species prefer to inhabit disturbed habitats. It also opposes other observations in this study (see below). In the former, the possible explanation is the meaning of the authors in the other studies when stating, 'prefer to inhabit disturbed habitat'. This presumably means the physiological preference, *i.e.*, many ginger species would grow vigorously in an open area in a disturbed forest; of course, if gingers grow vigorously in a disturbed forest, the forest would harbour many ginger species. It does not necessarily mean that disturbed forest is rich with gingers. Figure 1, even though it may be biased against this issue, shows that disturbed forest has fewer gingers.

We postulate two relationships between the logging disturbance and the composition of gingers in the study area. First, the logging causes a similar pattern of impact on the composition of gingers irrespective of locality, *i.e.*, it facilitates similar species of gingers to inhabit and dominate the disturbed area irrespective of the ecological condition of the area before the logging. This impact is indicated by the high similarity of species composition between the logging road in the study area and similar sites in other logged forests in Sabah. Secondly, montane gingers may be resilient to logging disturbance. The compositions of gingers along the line transect and at the side of the logging road were closely similar; in other words, the partially disturbed forest had a species composition similar with the heavily disturbed forest.

The explanation for the second assumption is that possibly in the study area the opening of the logging road and the timber felling did not cause the death of gingers through desiccation. The cool and cloudy weather of the study area, and the frequent rainfall may have maintained the viability of the ginger rhizomes in the open area. Again, rather than killing the gingers, logging may have facilitated their establishment by creating a canopy gap for the gingers. It has been known that gingers are light demander plants (Larsen *et al.*, 1999). Unfortunately, conventional comparison is inappropriate to support the assumption. Comparing the diversity of gingers in the logged forest with that in the primary forest (as control) is, by coincidence, inappropriate in our study. The sampled primary forest is situated at higher elevation and thus of different soil attributes; it is under the regulation of different ecological factors even during the time that the logged forest was still a primary forest.

In this very short-period study, it may be reasonable, however, to mention that the previous logging has had a negative but less obvious impact on the diversity of gingers in the study area; a long-term study is needed to understand clearly the impact of the logging.

Other than logging disturbance, the important factors that could also limit the recruitment and establishment of gingers in the study area are pollination and dispersal of its species, and this may be the reason why gingers poorly populate the study area and montane forests in general. Insects (Sakai, 1996; Sakai *et al.*, 1999), and rodents and birds (Sakai, 2000) are the pollinators and dispersers of gingers. It is possible that, in the study area, the abundances of pollinators and dispersers of gingers are very low. The probable impact linked to this problem that has been observed in the study area is that the gingers are locally abundant. Indirectly, this indicates that the species are poorly dispersed either due to their fruits not being dispersed far away from the fruiting individual or due to the unavailability of fruits for dispersal (as a consequence of poor pollination). In the latter condition, the species reproduces mainly from rhizomic division and thus it produces a compact and isolated clump of shoots.

The highly similar composition between the study area and the sites in the Crocker Range can be attributed to the fact that the study area and the areas in the Crocker Range are reported to be closely similar ecologically (Bowler *et al.* 1975). It has been reported that often, sites with a similar environmental condition will have a similar composition of gingers (Gobilik, 2002). The only exception of the latter rule are the 'montane gingers' of Sabah, which are thriving in lowland forests of Sarawak and Brunei. This phenomenon would be interesting to study in the future.

CONCLUSIONS

Four important conclusions can be drawn from this study. (1) The study area has fewer species of gingers compared to a few other sites in Borneo. (2) The species that are common along the logging road in the study area were also the species that are common under similar conditions in other logged forests in Sabah. (3) Probably montane gingers are resilient to logging disturbance. (4) The study area has a highly similar composition of gingers with three other sites in the Crocker Range. If such similarity is consistent for other areas in the Crocker Range, then the Trus Madi Range could serve as another conservation area for montane gingers in Sabah.

In addition, we speculate that, just as for other plants, soil attributes, low light intensity, and poor pollination and dispersal mechanisms are some of the major limiting factors to the spatial distribution of gingers in the Trus Madi Range.

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Appendix 1. The record of Zingiberaceae and Costaceae species in Borneo at different elevations, forest types, soil types and landforms.

	Elevation						Forest type			Soil type								Landform				Life form	
Species	Summit-area Zone (> 3 700 m)	Upper Sub-alpine forest (> 3 400-3 700 m)	Upper montane (> 2 300-3 400 m)	Lower montane forest (> 1400-2 300 m)	Submontane/ Hill Forest (600-1 400 m)	Lowlands (< 600 m)	Primary forest	Secondary forest	Swamp forest	Limestone	Ultramafic substrate	Sandstone	Podsolic soil	Sandy soil	Clay soil	Basalt soil	Alluvial (fertile soil e.g. loam)	Damp (moist) area	Stream bank	Rocky area	Ridge	Epiphyte	Total
Alpinia																							
A. amentacea R.M. Sm.																							
A. aquatica (Retz.) Rosc.					1	1	1					1			1								5
A. argentea (Burtt & Sm.) R.M. Sm.					1	1		1															3
A. beamanii R.M. Sm.					1																		1
A. aff. *brevilabris* Presl.						1		1															2
A. capitellata Jack					1						1	1											3
A. glabra Ridl.				1	1	1	1												1				5
A. glabra var. *reticulata* R.M. Sm.						1	1					1				1			1				5
A. hansenii R.M. Sm.					1	1															1		3
A. havilandii K. Schum.				1			1																2
A. latilabris Ridl.						1																	1
A. ligulata K. Schum.						1	1	1	1	1		1		1		1	1						9
A. martinii R.M. Sm.					1																	1	1
A. microlophon Ridl.					1													1					2
A. mutica Roxb.						1								1					1	1			4
A. nieuwenhuizii Val.				1	1	1	1							1					1				6
A. tamacuensis R.M. Sm.						1																	1
Amomum																							
A. angustipetalum Sakai & Nagam.							1											1	1				3
A. anomalum R.M. Sm.					1	1									1				1				4
A. aff. *anomalum* R.M. Sm.						1																	1
A. biflorum Jack.																							
A. bicorniculatum K. Schum.																							
A. bilabiatum Sakai & Nagam.							1												1				2
A. borneense (Schum.) R.M. Sm.						1																1	1
A. botryoideum Cowley												1			1			1	1				4
A. burttii R.M. Sm.				1																			1
A. calyptratum Sakai & Nagam.						1											1		1		1		4
A. cerasinum Ridl.																							
A. compactum (Sol. ex.) Maton																							
A. coriaceum R.M. Sm.						1													1				2
A. dictyocoleum K. Schum.				1															1				2
A. durum Sakai & Nagam.						1													1				2
A. epiphyticum R.M. Sm.																							
A. flavidulum Ridl.																							

continued Appendix 1

A. flavoalbum R.M. Sm.		1																		1	1
A. gyrolophos R.M. Sm.				1													1				2
A. hansenii R.M. Sm.			1										1				1				3
A. kinabaluense R.M. Sm.		1																			1
A. lambirense R.M. Sm.				1													1				2
A. laxisquamosum K. Schum.				1													1				2
A. ligulatum R.M. Sm.			1																		1
A. longipedunculatum R.M. Sm.	1	1																			2
A. luteum R.M. Sm.																	1				1
A. macroglossum K. Schum.																					
A. nicolii R.M. Sm.																					
A. oliganthum K. Schum.			1	1											1		1				4
A. paucifolium R.M. Sm.																					
A. dimorphum M. Newman				1													1	1			3
A. pungens R.M. Sm.				1		1											1				3
A. borealiborneense Turner																					
A. roseisquamosum Nagam. & Sakai				1													1			1	2
A. sarawacense K. Schum.				1			1														2
A. sceletescens R.M. Sm.		1	1																		2
A. staminidivum Gobilik, Lamb & Poulsen				1																	1
A. somniculosum Sakai & Nagam.				1		1													1		3
A. testaceum Ridl.				1	1																2
A. uliginosum Koenig																					
A. xanthophlebium Bak.			1	1															1		3
Burbidgea																					
B. longilora (Ridl.) R.M. Sm.																					
B. nitida Hook. f.																					
B. pauciflora Val.																					
B. schizocheila Hack.		1	1	1				1							1					1	5
B. stenantha Ridl.	1		1	1				1							1		1			1	6
Elettaria																					
E. brachycalyx Sakai & Nagam.			1																		1
E. kapitensis Sakai & Nagam.			1		1											1					3
E. linearicrista Sakai & Nagam.			1														1				2
E. longipilosa Sakai & Nagam.																	1				1
E. longituba (Ridl.) Holtt.				1									1				1				3
E. rubida R.M. Sm.			1	1									1				1				4
E. stoloniflora (Schum.) Sakai & Nagam.			1	1												1	1				4
E. surculosa (Schum.) Burtt & R.M. Sm.			1								1						1				
Elettariopsis																					
E. curtisii Bak.																					
E. kerbyi R.M. Sm.			1														1				2
E. stenosiphon (Schum.) Burtt & R.M. Sm.																					
Etlingera																					
E. inundata Sakai & Nagam.																					
E. baramensis Sakai & Nagam.							1										1				
E. brachychila (Ridl.) R.M. Sm.		1																			1
E. belalongensis A.D. Poulsen				1	1																2
E. aff. *brevilabrum* (Val.) R.M. Sm.			1	1	1	1															4
E. brevilabrum (Val.) R.M. Sm.				1	1	1															3
E. corrugata A.D. Poulsen & Mood				1	1										1		1				4
E. fimbriobracteata (Schum.) R.M. Sm.			1	1									1				1				4
E. littoralis (Koenig) Giseke			1	1												1					3

continued Appendix 1

E. longipetiolata (Burtt & Sm.) R.M. Sm.																			
E. metriocheilos (Griff.) R.M. Sm.		1																	1
E. muluensis R.M. Sm.			1				1		1		1					1			5
E. aff. *muluensis* R.M. Sm.	1																		1
E. nasuta (Schum.) R.M. Sm.																			
E. nasuta var. *reticulata* R.M. Sm.		1									1								2
E. newmanii Sakai & Nagam.																			
E. pubescens (Burtt & Sm.) R.M. Sm.																			
E. aff. *pubescens* (Burtt & Sm.) R.M. Sm.																			
E. coccinea (Bl.) Sakai & Nagam.		1	1	1	1						1				1	1			7
E. aff. *punicea* (Roxb.) R.M. Sm.																			
E. pyramidosphaera (Schum.) R.M. Sm.		1		1	1							1				1		1	6
E. rubromarginata A.D. Poulsen & Mood			1	1							1				1				4
E. sanguinea (Ridl.) R.M. Sm.																			
E. sessilanthera R.M. Sm.			1										1	1	1	1		1	6
E. triorgyalis (Bak.) R.M. Sm.															1				1
E. velutina (Ridl.) R.M. Sm.	1																		1
Geocharis																			
G. fusiformis var. *borneensis* R.M. Sm.			1													1			2
G. rubra Ridl.		1	1				1								1				4
Geostachys																			
G. penangensis Ridl.			1												1			1	3
Hornstedtia																			
H. conica Ridl.																			
H. gracilis R.M. Sm.	1	1																	2
H. havilandii (Schum.) K. Schum.		1	1																2
H. incana R.M. Sm.	1																		1
H. leonurus (Koenig) Retz.																			
H. scyphifera (Koenig) Steud.		1																	1
H. tomentosa (Bl.) Bakh. f.																			
H. reticulata K. Schum.		1	1	1	1														4
H. pininga var. *borneense* R.M. Sm.		1																	1
H. phaeochoana (K. Schum.) K. Schum.																			
H. affinis Ridl.																			
H. minor (Bl.) K. Schum.			1											1					2
Plagiostachys																			
P. albiflora Ridl.		1	1													1	1		4
P. bracteolata R.M. Sm.		1													1				2
P. breviramosa Cowley		1	1	1	1											1			5
P. crocydocalyx (Schum.) Burtt & R.M. Sm.		1			1		1									1			4
P. glandulosa Sakai & Nagam.																			
P. parva Cowley		1	1											1					3
P. aff. *parva* ined.																			
P. poringensis Cowley ined.		1																	1
P. strobilifera (Bak.) Ridl.		1	1													1		1	4
Tamijia																			
T. flagellaris Sakai & Nagam.																			
Boesenbergia																			
B. apiculata (Val.) Loesen.																			
B. armeniaca Cowley					1						1			1	1	1			5
B. aurantiaca R.M. Sm.			1	1						1				1	1	1			6
B. burttiana R.M. Sm.			1									1							2
B. cordata R.M. Sm.			1	1			1							1					4

continued Appendix 1

B. flavoalba R.M. Sm.			1							1	1				1					4
B. flavorubra R.M. Sm.		1	1				1													3
B. gracilipes (Schum.) R.M. Sm.			1	1																2
B. grandifolia (Val.) Merr.																				
B. grandis R.M. Sm.			1				1													2
B. hirta (Ridl.) Merr.																				
B. hosensis Cowley																1				1
B. hutchinsoniana Burtt & R.M. Sm.		1	1				1													3
B. kerbyii R.M. Sm.			1												1					2
B. oligosperma (Schum.) R.M. Sm.																				
B. orbiculata R.M. Sm.		1	1				1		1			1		1						6
B. ornata (N.E. Br.) R.M. Sm.																				
B. parva (Ridl.) Merr.			1									1				1				3
B. pulchella (Ridl.) Merr.		1	1	1			1					1		1		1				7
B. pulchella var. *attenuata* R.M. Sm.			1			1														2
B. stenophylla R.M. Sm.		1													1	1		1		4
B. striata (Val.) Loesen.																				
B. variegata R.M. Sm.			1	1			1					1		1						5
Camptandra																				
C. parvula var. *angustifolia* Ridl.			1	1					1						1		1			5
Haplochorema																				
H. decus-sylvae (Hall. f.) Val.			1																	1
H. pauciflorum R.M. Sm.															1					1
H. pauciflorum var. *bullatum* R.M. Sm.		1														1				2
Hedychium																				
H. borneense R.M. Sm.		1																		1
H. cylindricum Ridl.	1	1						1	1										1	4
H. muluense R.M. Sm.	1	1					1		1					1		1			1	6
H. lineare R.M. Sm.			1	1															1	2
Scaphochlamys																				
S. argentea R.M. Sm.			1												1					2
S. petiolata (Schum.) R.M. Sm.																				
S. polyphylla (Schum.) Burtt & R.M. Sm.			1																	1
S. reticosa (Ridl.) R.M. Sm.							1													1
S. aff. *breviscapa* Holtt.							1													1
Globba																				
G. atrosanguinea Teysm. & Binn.		1	1	1			1		1					1		1				7
G. brachyanthera K. Schum.		1													1					2
G. brachyanthera var. *hirsuta* R.M. Sm.		1		1																2
G. brachyanthera var. *rubra* R.M. Sm.		1														1	1			3
G. franciscii Ridl.	1	1	1				1							1						5
G. muluensis R.M. Sm.			1			1								1		1				4
G. pendula Roxb.		1	1	1					1							1				5
G. propinqua Ridl.	1	1	1	1													1			5
G. pumila Ridl.			1											1	1		1			4
G. tricolor Ridl.		1			1											1				3
G. tricolor var. *gibbsiae* (Ridl.) R.M. Sm.		1	1	1	1				1		1			1		1	1			9
Zingiber																				
Z. acuminatum var. *borneense* Val.			1				1							1						3
Z. albiflorum R.M. Sm.		1																		1
Z. argenteum Theilade & Mood			1	1			1													3
Z. chlorobracteatum Theilade & Mood		1			1															2
Z. coloratum N.E. Br.		1																		1

continued Appendix 1

Z. eborinum Mood & Theilade				1		1															2
Z. flagelliforme Theilade & Mood				1	1					1											3
Z. flammeum Theilade & Mood				1	1																2
Z. georgeii Theilade & Mood						1											1				2
Z. griffithii Ridl.				1	1	1	1										1				5
Z. incomptum Burtt & R.M. Sm.			1																		1
Z. kelabitianum Theilade & Christensen			1		1	1	1										1				5
Z. lambii Mood & Theilade				1	1				1												3
Z. latifolium Theilade & Mood		1				1															2
Z. leptostachyum Val.																					
Z. longipedunculatum Ridl.			1	1		1		1									1	1			6
Z. martinii R.M. Sm.																1	1				2
Z. odoriferum Bl. var. *borneense* Val.																					
Z. ophiofolium Theilade & Mood ined.																					
Z. pachysiphon Burtt & R.M. Sm.				1		1								1			1	1			5
Z. pendulum Mood & Theilade		1			1																2
Z. philipsii Theilade & Mood			1		1	1															3
Z. porphyrosphaerum K. Schum.																					
Z. pseudopungens R.M. Sm.			1						1												2
Z. puberulum var. *borneense* R.M. Sm.								1													1
Z. purpureum Rosc.																					
Z. velutinum Theilade & Mood					1	1				1					1		1				5
Z. vinosum Mood & Theilade				1	1											1					3
Z. viridiflavum Theilade & Mood			1	1	1												1				4
Costus																					
C. speciosus (Koenig) R.M. Sm.		1	1	1		1															4
C. globosus Bl.			1	1													1				3
C. aff. *globosus* Bl.			1														1				2
C. aff. *microcephalus* K. Schum.				1	1																2
C. paradoxus K. Schum.				1								1					1				3
Number of species (N sp)	2	22	74	94	43	26	6	22	4	15	3	11	13	4	23	25	65	10	9	9	
% (N sp/ 206 species in Borneo)	1	11	36	46	21	13	3	11	2	7	1	5	6	2	11	12	32	5	4	4	
Number of observation	192					75						95					109			9	480

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