
Research Article

Notes on species composition and ornamental gingers in Tawau Hills Park, Sabah**Januarius Gobilik^{1*} and Simun Limbawang²**

¹*Universiti Malaysia Sabah, School of Sustainable Agriculture, Locked Bag No. 2073, 88999 Kota Kinabalu, Sabah, Malaysia. *email: jgobilik@ums.edu.my*

²*Sabah Parks, Tawau Hills Park, P.O Box 62103, 91031 Tawau, Sabah, Malaysia.*

ABSTRACT. This paper updates the composition of species and reports on ornamental gingers at Tawau Hills Park, Sabah. The gingers were recorded within 10 m to the left and right of the 15-km-long nature trail and 4-km-long forest *rentis*. Sixty-four species from 13 genera were documented. Thirty-eight percent and 28 % of the gingers in Sabah and Borneo, respectively are found within the Park. Of these species, seven are likely to be new to science and endemic to this area, and 19–29 species were evaluated as attractive and may be exploited for landscaping. One species, *Boesenbergia pulchella*, was found growing only several metres from the edge of the hot spring, which indicates that it could tolerate soil of high sulfur content and that it may have survived this harsh condition through years of acclimatization. This observation suggests that time and a little effort are required for successful planting of delicate ornamental gingers in unfavourable soil condition in a desired location in a garden. During the survey, *Schapochlamys* was not encountered along the trail where it was reported to occur previously. The results of this study suggest that the park harbours many ornamental gingers and plays an important role in the conservation of these plants in Sabah.

Keywords: Zingiberaceae, species richness, ornamental, Borneo.

INTRODUCTION

The composition of gingers in Tawau Hills Park was first reported in 1999 (Ibrahim, 1999). Thirty-six species from 14 genera were documented. One of the notable findings was six taxa were suggested as new to science with four as new species and two as new varieties. The occurrence of *Schapochlamys*, a genus that is thought to be restricted to Sarawak (Smith, 1986), was also reported. Ibrahim (1999) implied that gingers in the park were diverse.

Since 1999, sporadic collections of gingers were made from the park. From these collections, several new species were described (Poulsen, 2006; Julius *et al.*, 2007) with some of the species thought to have attractive vegetative characteristics. Although the publication of these new species are good publicity, generally, few reports have been published on gingers of the park. Therefore, there is a need to update information on the diversity, ecology and other aspects of gingers in this area. This information would be useful in the conservation of Sabah's gingers and also in promoting the commercial potential of the plants, especially for landscaping.

In 2005, a group of researchers from

the Forest Research Centre, Sabah Forestry Department, carried out a botanical survey in this park, which the authors participated. This survey aimed to document the richness and ornamental potential of gingers in this area. These findings are presented in this paper.

MATERIALS AND METHODS

Tawau Hills Park (4°14' 42.7" N, 117°53' 03.3" E) is predominantly a mixed dipterocarp forest. Its elevation ranges from 100 to 1310 m above sea level, covering a wide range of forest habitats such as hot spring, lowland, montane, riverine and heath forests. The Park's total area is almost 28,000 ha and is managed by Sabah Parks as a water catchment and also for tourism activities.

The gingers were documented along a 15km-long nature trail, starting from the riverbank near the headquarters of the park to the peak of Mt. Lucia (1201 m a.s.l.) and extending halfway to the trail leading to Mt. Magdalena (1310 m a.s.l.) on 5 July 2005. In addition, two 2 km-long of forest *rentis* were established perpendicular to the nature trail, starting from the expedition campsite near a place called 'Hostel Helipad', located about 2.3 km from the peak of Mt. Lucia. One *rentis* went towards Sg. Merotai at the north and another to Sg. Tawau at the south of the nature trail. Gingers within 10 m to the left and right of the nature trail and the forest *rentis* were documented. Botanical specimens of flowering gingers were collected, processed, and kept at SAN or SP herbarium. Flowers were preserved in 70 % methyl-acetate-alcohol. The specimens were identified using taxonomic keys from recent publications on gingers. Documentation was also carried out along the ginger trail at the 'Lowland Garden', an area where gingers from other parts of the park were transplanted.

Ornamental potential of the gingers were evaluated on the spot. Since the criteria for

such evaluation is not yet available, the first author set four informal categories to classify the ornamental potential of the gingers based on his experience in planting of gingers for landscaping. The four informal categories applied are (1) ornamental and can easily be commercialised for landscaping; (2) ornamental and has commercial potential but it will create a visual appeal only if planted in a big cluster; (3) can be used for landscaping but depending much on the creativity of the landscaper; and (4) ordinary appearance in that the leaves are just plain green, or its flower is noticeable, but its flowering season is irregular, leaving it green most of the time. Species categorised under the first group are distinguishable by their large size, showy and colourful inflorescences or leaves, and sometimes with conspicuous leaf arrangement. The second group has species that are noticeable for cumulative appearances, in which they form uniformity in terms of size and colour of leaves or inflorescences but only when planted in big clusters. The third group has species that are noticeable for their large size, but has less prominent inflorescence or leaf colour, hence, landscapers can still use them, depending on their creativity. Species classified under the fourth group are usually small or moderately large, the leaves are dull green, and the inflorescences are beautiful but tiny or large but of dull colour; they are thought to have a low potential for landscaping.

RESULTS AND DISCUSSION

General species composition

Sixty-four species from 13 genera were documented (Appendix 1 and 2). Forty-six species were collected from the nature trail and forest *rentis*, and 16 were recorded from the ginger trail at the 'Lowland Garden'. Two records of species from Ibrahim (1999) were included, as they were not collected during the expedition. The amount of gingers collected in this survey is 78 % higher than that of previous reports, and this can be attributed

to the extensive ground survey done in this study. This survey accounted for 38 % of the gingers in Sabah and 28 % of that in Borneo. Sabah has 168 species of gingers (Gobilik, 2008) and Borneo has around 229 species: this figure was updated from Gobilik & Mashitah (2005) based on the recent publications of new gingers in Borneo by Gobilik *et al.* (2005a), Lim & Lau (2006), Poulsen (2006b), and Julius *et al.* (2007).

From this survey, 47 species were positively identified as known species in Sabah, eight taxa were identified only to the closest species that resemble them morphologically in Sabah, and nine were identified only to genera. Thirty-six species are common in Sabah (56 %), 15 rare (23 %), seven possibly endemic to the park (11 %), four widespread (6 %), and two frequent but not common (3 %). Four species were described only recently: *Etilingera albolutea*, *E. baculutea*, *E. aurantia*, *E. rosamariae*, and *Plagiostachys roseiflora* (Poulsen, 2006b; Julius *et al.*, 2007). *Etilingera albolutea* and the *Plagiostachys* are two of the species noted by Ibrahim (1999) as new species. The other new species or varieties (*Zingiber*, *Etilingera* and *Alpinia* species) noted by her as undescribed.

It has been found that the four most speciose genera (with more than five species) are *Etilingera* (15), *Amomum* (9), *Zingiber* (9), and *Plagiostachys* (7). These represent 54, 33, 50, and 41 % of the species in these genera in Sabah, respectively. Genera having only one or two species are *Globba* (2), *Hedychium* (2), *Burbidgea* (1), and *Elletariopsis* (1), that are 33, 50, 33, and 25 % of the species in these genera in Sabah, respectively. *Geocharis* was also encountered in the area with only one species, which is the only species occurring in Sabah.

The park is found to have a higher number of gingers (64 species) compared to

Mt. Kinabalu (58 species), Imbak Canyon Conservation Area (48), Tabin Wildlife Reserve (46), Crocker Range Park (42), Serudong (39), Danum Valley (36), and Mt. Trus Madi Area (25) (See Magintan, 2000; Gobilik, 2002; Gobilik & Mashitah, 2005; Gobilik *et al.*, 2005b; Gobilik, 2008). The number of ginger species in Tawau Hills Park is only two species lower than that of Maliau Basin (66 species; see Julius *et al.*, 2010). Most of the records from the other forest reserves, however, are based on studies carried out some years ago. Hence, with new intensive enumeration of the ginger species in these forest reserves, the figure may change.

Seven of the species reported by Ibrahim (1999) were not collected during the survey. The notable one is the *Scaphochlamys petiolata* K. Schuman. It was not encountered in this survey, although, it was reported to occur in one of the trails in the park. Two more species were *Amomum* cf. *hansenii* R.M. Smith and *Globba franciscii* Ridley; the former is rare in Sabah and the latter is common. The rest were two species of *Amomum* and *Zingiber*, respectively. The latter four species were not accounted into the total count of gingers in the park, as these species are suspected to be four of the nine unidentified species in this study.

There are two possibilities as to why *Scaphochlamys* was not collected during the survey. Firstly, it might have been overlooked as the plant may have been at its non-reproductive stage during the survey. When in sterile condition, *Scaphochlamys* is easily mistaken for *Boesenbergia*, as species in both these genera are similar morphologically. This close similarity has often caused *Boesenbergia* to be misidentified as *Scaphochlamys*. Another explanation may be related to the dark condition in the forest understorey, and thus searching for this tiny ginger is not an easy task.

Thus far, *Scaphochlamys petiolata* is known to occur only in Sarawak (Poulsen, 2006a). Even so, its occurrence in Sabah is possible, learning from the scenario of the *Geostachys*. At one time, *Geostachys* was doubted to occur in Sabah, but the discovery of its fertile specimens in Maliau Basin led to the first description of its species in Sabah (Lim & Lau, 2006). As for the *Scaphochlamys*, several collection trips to the park at different times of the year will answer the possibility of its occurrence in Sabah.

Ornamental species

Based on the four informal categories evaluated for the gingers' attractiveness, 19 species are grouped in Group 1, nine in Group 2, another 22 in Group 3, and 12 in Group 4 (Appendix 1 and 2). The other two species, which were added from Ibrahim's (1999) list, were placed in Group 2 (*G. franciscii*) and 4 (*A. cf. hansenii*), respectively. These results show that between 19 to 29 gingers in the park can be exploited for landscaping. The species are mainly from Group 1 and 2.

The species were again classified into three more groups based on practicality in landscaping. In this classification, the gingers were not differentiated based solely on attractiveness but also on the feasibility in propagation, planting, maintenance, and gaining visitors' attention. The first choice species suggested for landscaping are therefore *Alpinia aquatica*, *A. dimorphum*, *Etilingera albolutea*, *E. baculutea*, *E. elatior*, *E. pubescens*, *E. pyramidosphaera*, *Zingiber cf. albiflorum*, *Z. flagelliforme*, *Z. pseudopungens*, *Z. cf. gracile*, *Zingiber* sp. A–C, *Z. vinosum*, and *Z. viridiflavum*. The second choice species are *Amomum coriaceum*, *A. testaceum*, *Amomum* sp. A, *Etilingera fimbriobracteata*, and *Geocharis fursiformis* var. *borneense*. The third choice species are *Boesenbergia pulchella*, *Boesenbergia* sp. B, *Burbidgea cf. schizocheila*, *Globba franciscii*, *G. pendula*,

G. propinqua, *Hedychium muluense*, and *Hedychium* sp. A. *Hornstedtia scyphifera* was not treated here, as although it is comparatively attractive for landscaping, its decorative uses are limited and it is not a generalist. Its natural habitat is at high elevation, and this preference is associated with cool weather and high precipitation of the area. However, gardens established on high elevation are almost unknown in Malaysia and therefore, this fact limits the use of this species in landscaping.

The first choice species are the easiest to exploit, followed by the second and third choices. The first choice is mainly species of *Etilingera* and *Zingiber*, with a few from *Alpinia* and *Amomum*. These species are noticeable to visitors and are easy to maintain, as the species can adapt to a wide range of ecological conditions, and they may be able to make a remarkable change in an open area in only a few months. The species grow relatively fast, can grow to more than one and a half metres tall, and form compact clusters; they have wide and long leaves, some have purple lower leaf surfaces, with large and coloured inflorescence bracts and flowers. The second choice species are less attractive compared to the first and third choices, but they are large, may grow relatively fast, and form compact clusters, and are easy to maintain. Species within the third choice are attractive compared to the second and even to some of the first choice species, but they need extra care upon transplanting, since they have narrow ecological preference in their natural habitat. On transplanting, they grow relatively slow to form noticeable clusters, although in the wild, they grow rapidly and can be found in large clusters.

Two of the species, *Amomum* sp. A and *Zingiber cf. gracile*, are not only attractive but could also be important as resources for screening of useful compounds. The *Amomum* has large fruits, which resemble that of the popular and commercial *A. subulatum* Roxburgh. The *Zingiber* has bulbous and

fleshy rhizome, which resemble that of *Zingiber officinale* Roxburgh, the spice ginger. This characteristic is unusual for wild *Zingiber* in Sabah.

General ecological observations

One of the species, *Boesenbergia pulchella*, a small delicate ginger, was found to tolerate high sulfur content soil, an ecological trait that is rarely reported for gingers. A few patches of this species were growing only a few metres away from the edge of the hot spring. Hence, it is logical to assume that it has gradually acclimatised to this soil and has even survived floods. In other parts of Borneo, *Boesenbergia* is known to tolerate poor soil condition where many other plants do not grow, such as in limestone soil. This genus is found abundantly at the Dagat limestone area in Tabin Wildlife Reserve, Sabah (Gobilik *et al.*, 2003), and at the Mulu limestone area, Sarawak (Smith, 1982). The observations in this study and that in the literature suggest that growing *Boesenbergia* outside its natural habitat could be difficult but possible.

The altitudinal distribution of the ornamental gingers was not quantitatively documented because of time constraints, but general observations on the ground indicated that most of them display similar distribution patterns as described for them in other areas in Sabah (Gobilik & Mashitah, 2005). This observation indicates that they can be used to landscape areas within the range of elevation mentioned in Gobilik & Mashitah (2005). Some of the species have their centre of natural distribution in high elevation areas: *A. dimorphum*, *E. pubescens*, *H. scyphifera* and *Z. pseudopungens*.

Most of the ornamental gingers were found to prefer moist areas such as riverbanks, stream banks, and edges of natural ponds. We observed on the ground that production of tillers was robust whenever the species grew

adjacent to water resources. This observation is consistent with personal observations done in other parts of Sabah by the first author and other ginger enthusiasts in Sabah (Anthony Lamb, pers. comm.). Therefore, a good watering regime has to be implemented to support gingers after they have been transplanted into a garden. Such a regime is almost compulsory if the transplanting involves highland species.

Two of the highland species in Sabah, however, can be transplanted in lowland areas with ease, namely *A. nieuwenhuizii* and *Z. pseudopungens*. This is because they are found to be non-obligatory to high elevations. These species can be found abundantly in the lowland areas where the annual precipitation is high (Anthony Lamb, pers. comm.). In the park, these species were found growing mostly in the lowland area.

CONCLUSION

This study suggests that the park plays an important contribution to the conservation of gingers in Sabah. It harbours a vast number of gingers with many possibly new to science, and they have vast potential for ornamental purposes such as for landscaping.

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Appendix 1. List of gingers collected in Tawau Hills Park.

No.	Species	Notes	Notes on Attractiveness (Group)	Notes on Distribution in Sabah
1.	<i>Alpinia havilandii</i> K. Schum	Herb, 0.9 m tall, leaves and stem light green, tiller robust. Trail to Mt. Magdalena (1310 m a.s.l.), on riverbank, lowland primary forest. <i>J. Gobilik et al. 1061.</i>	Inflorescence tall and large. But its use in landscaping is limited to the water edges (3 or 2)	Common, especially in riverine forest
2.	<i>Alpinia nieuwenhuizii</i> Val.	Herb, 1.2 m tall, leaves and stem green. Trail to Mt. Magdalena, on riverbank, lowland primary forest. <i>J. Gobilik et al. 1056.</i> A comparable specimen is HI502, which could be a hybrid between <i>A. ligulata</i> and <i>A. nieuwenhuizii</i> (Ibrahim, 1999).	Flowering all year round, inflorescence large, fruits reddish and large. But its flowers are small (3 or 2)	Common, especially in riverine forest and areas of high precipitation
3.	<i>Amomum borealiborneense</i> I.M. Turner	Herb, 0.3 m tall, leaves and stem dark green, inflorescence bracts brown, papery. 2.3 km from the peak of Mt. Lucia (1201 m a.s.l.), along <i>rentis</i> to Sg. Tawau, lowland primary forest. <i>J. Gobilik et al. 1095.</i>	Leaf arrangement is noticeable, but otherwise it is just plain green (4 or 3)	Common, especially in the east coast
4.	<i>Amomum coriaceum</i> R.M. Smith	Herb, 1.3 m tall, base with strong stilt roots, leaf sheath yellowish green. Trail to Galas waterfall, on riverbank, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1077.</i>	Stilt roots conspicuous, inflorescence bract margin fringing (2)	Common, especially in the east coast, south, and south west
5.	<i>Amomum dimorphum</i> M. Newman	Herb, 0.3 m tall, juvenile, base reddish, leaf sheath yellowish, rigid, root strong and rigid. Trail to Mt. Lucia, near the 'Kerangas' forest patch.	Inflorescence and fruits large, showy and colourful. (1)	Common, especially in Tawau, interior, south and south west
6.	<i>Amomum laxisquamosum</i> K. Schum.	Herb, 1.1 m tall, leaves and stem green, base with strong stilt roots, inflorescence bracts brown, flowers orange. Galas waterfall, riverbank, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1080.</i> Herb, 1.4 m tall, leaves and stem green, inflorescence bracts brown, papery. 2.3 km from the peak of Mt. Lucia, along <i>rentis</i> to Sg. Tawau, on riverbank, lowland primary forest. <i>J. Gobilik et al. 1099.</i>	Flowers showy yellow (3 or 2)	Common

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| 7. <i>Amomum oliganthum</i> K. Schum. | Herb, 1.2 m tall, leaves and stem dark green, petiole base reddish, inflorescence bracts green, fruits reddish, spiny, calyxes brown. Trail to hot spring, adjacent to river, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1102.</i>
Herb, 1.6 m tall, leaves and stem dark green, inflorescence bracts yellow to green, flowers orange yellowish. <i>Rentis</i> from expedition campsite (near the Hostel Helipad) to Sg. Tawau, lowland primary forest. <i>J. Gobilik et al. 1093.</i> | Flowers showy yellow; fruits large, red and with soft spines (3) | Common, especially in the east coast |
| 8. <i>Amomum</i> cf. <i>oliganthum</i> K. Schum. | Herb, 2 m tall, leaves and stem dark green, fruits dark green, spiny. Trail to hot spring, near the second river, on riverbank, lowland primary forest, inundated area. <i>J. Gobilik et al. 1072.</i> | Flowers showy yellow; fruits large, dark green and spiny (3) | Its large size is unusual for <i>A. oliganthum</i> . Otherwise, it is also common just as the former. |
| 9. <i>Amomum</i> sp. A | Herb, 1.5–2.2 m tall, leaves and stem dark green, base with strong stilt roots, fruits dark green, clustered, 4–5 x 2–3 cm. Trail to hot spring, adjacent to river, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1105.</i> Herb, 2 m tall, leaves and stem dark green, fruits dark green. 1 km before the expedition campsite, lowland primary forest. <i>J. Gobilik et al. 1086.</i> Similar to HI475 in Ibrahim (1999). | Stilt roots prominent and fruits large (2) | Rare; other records are from Danum Valley and Mt. Kinabalu. |
| 10. <i>Amomum staminidivum</i> J. Gobilik, A. Lamb & A.D. Poulsen | Herb, 0.6 m tall, leaves and stem dark green, fruits green, spiny (soft spines). <i>Rentis</i> from the expedition campsite to Sg. Tawau, lowland primary forest. <i>J. Gobilik et al. 1084.</i> Herb, 0.7 m tall, leaves and stem green, fruits green with soft spines. <i>Rentis</i> from expedition campsite to Sg. Merotai, lowland primary forest. <i>J. Gobilik et al. 1091.</i> | At a suitable site, it grows gregariously to form conspicuous clusters (4 or 3) | Common, but not locally abundant; other records are from Imbak Canyon Conservation Area, Serudong, and Nabawan |

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| 11. | <i>Amomum testaceum</i> Ridl. | Herb, 1.2 m tall, leaves and stem dark green, crushed leaves smell of eucalypt oil, inflorescence bracts brown, papery, fruits white. Trail before the junction to Galas waterfall and hot spring, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1076.</i> | It forms a dense and large cluster, making it noticeable; bears mass flowering and fruiting (1) | Common |
| 12. | <i>Boesenbergia pulchella</i> (Ridl.) Merr. | Herb, 10 cm tall, base reddish, leaf sheaths yellowish green, flower white (forming pouch) with red dots on the apical margin. Trail to Mt. Magdalena, lowland primary forest. <i>J. Gobilik et al. 1057.</i> Widespread at the expedition area. Some patches grow several metres from the hot spring. | Flowers white (2) | Widespread |
| 13. | <i>Boesenbergia</i> sp. A | Herb, 10 cm tall, flowers white, labellum white with red smear on the central part, flanked by yellow smears. Trail to hot spring, on riverbank, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1106.</i> | Noticeable, only if planted in clusters (2 or 3) | Common, but identification is problematic |
| 14. | <i>Elettaria longituba</i> (Ridl.) Holtt. | Herb, 1.1 m tall, inflorescence trailing just above or embedded in the ground, flowers white, reddish smear on labellum. Trail to Galas waterfall, forest of superficial disturbance, lowland. <i>J. Gobilik et al. 1078.</i> Similar to HI504 (Ibrahim, 1999). | It forms noticeable cluster, but flowers are too small to be noticeable (3) | Common |
| 15. | <i>Elettaria surculosa</i> (K. Schum.) Burtt & R.M. Smith | Herb, 0.7 m tall, leaves dark green, inflorescence trailing on the ground, bracts pale pink, flowers white, labellum white with green central smear, the central smear flanked by red smears. <i>Rentis</i> from expedition campsite to Sg. Tawau, lowland primary forest. <i>J. Gobilik et al. 1090.</i>
Herb, 0.6 m tall, leaves deeply dark green. Trail to Mt. Magdalena, 50 m after the junction to the peak of Mt. Lucia, primary forest, lowland forest with prominent lower montane characteristics. <i>J. Gobilik et al. 1043.</i> | It forms noticeable cluster, but flowers are too small to be noticeable (3) | Rare. It differs from <i>E. longituba</i> by the green smear on the labellum. |

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| 16. | <i>Elettariopsis kerbyi</i> R.M. Smith | Herb, 0.6 m tall, leaves dark green, flower white, bracts pale green, labellum white with pale red central smear, the central smear flanked by yellow smears. Trail to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1046</i> (SAN). Herb, 0.6 m tall, base pale white, leaf sheaths green, leaves dark green, produces pungent smell when crushed. Trail from Mt. Lucia to Mt. Magdalena, first river, few metres from riverbank, lowland primary forest. <i>J.Gobilik et al. 1062</i> . | Flowers white with yellow and red smears (4, 3 or 2) | Common |
| 17. | <i>Etilingera albolutea</i> A.D. Poulsen & J. Mood | Herb, 0.8 m tall, leaf sheaths yellowish green to purplish towards the top, leaves dark green above, burgundy underneath. Trail to Mt. Magdalena, on riverbank, under forest gap, lowland primary forest. <i>J.Gobilik et al. 1054</i> . Herb, 1.2 m tall, leaf sheaths reddish, petiole yellowish green, leaves slightly plicate, fruits green, embedded in soil. Trail to Sg. Merotai, 300 m from the expedition campsite (2.3 km from the peak of Mt. Lucia), forest gap edge, lowland primary forest. <i>J.Gobilik et al. 1063</i> . | Stems red, inflorescence showy, leaves slightly plicate (1) | Rare, but locally abundant in Tabin Wildlife Reserve; the other record is from Danum Valley (it may be brought in from other places and planted there) |
| 18. | <i>Etilingera aurantia</i> A.D. Poulsen & H. Ibrahim | Herb, 1.6 m tall, stem reddish, petiole base reddish, inflorescence bracts pale green, calyx yellowish orange, flowers orange, stigma red. Trail to hot spring, on riverbank, forest of minor natural disturbance, lowland. <i>J.Gobilik et al. 1108</i> . | Stems green to reddish, flowers showy, but it grows away from the germination spot, a 'walking ginger' (3 or 2) | Rare; other records are from Danum Valley and Maliau Basin |
| 19. | <i>Etilingera baculutea</i> A.D. Poulsen & H. Ibrahim | Herb, 1.5 m tall, leaf sheaths yellowish green, leaves pale green, sometimes purplish underneath, flowers yellow, labellum tip and side of the lobe edge red, fruits pale green to pale whitish brown. Trail to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al, 1045</i> . Herb, c. 1 m tall, upper leaves green underneath burgundy, juvenile. Trail from Mt. Lucia to Mt. Magdalena, first river, near riverbank, lowland primary forest. <i>J.Gobilik et al. 1044</i> . | It forms a cluster, lower leaf surface burgundy, flowers yellow with reddish tips (1) | Rare; other records are from Crocker Range, Trusmadi Range and Maliau Basin |

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| 20. | <i>Etilingera brevilabrum</i> (Val.) R.M. Smith | Herb, 1.2 m tall, leaves with red blotches. Trail to Sg. Merotai, 300 m from the expedition campsite (2.3 km from the peak of Mt. Lucia), lowland primary forest. <i>J.Gobilik et al. 1064</i> . | Leaves with red blotches, a 'walking ginger' (4 or 3) | Widespread, especially in disturbed forest |
| 21. | <i>Etilingera cf. crispata</i> C.K. Lim | Herb, 2.2 m tall, inflorescence bracts brown, papery, fruits white, c. 4cm-long calyx remain on top. Trail to hot spring, near river, naturally disturbed forest, lowland. <i>J.Gobilik et al. 1101</i> . It differs from <i>C. crispata</i> by the lack of hanging stilt roots and round white hairy fruits. | Stilt roots prominent, flowers red, fruits pink (3 or 2) | Tawau Hills Park; this could be a new record of <i>E. crispata</i> in Sabah. |
| 22. | <i>Etilingera cf. amomoides</i> A.D. Poulsen | Herb, 1.5 m tall, stems consecutively connected in a straight row through above ground rhizomes. Trail from Mt. Lucia to Mt. Magdalena, after second river, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1051</i> . | Rhizome systematically connected one to another to form interesting pattern (4 or 3) | Rare; other records are from Trusmadi Range and Crocker Range (Long Pasia & Long Miau) |
| 23. | <i>Etilingera inundata</i> Sakai & Nagamasu | Herb, 0.6 m tall, green all over, base with conspicuous patches of hairs. Trail to Sg. Merotai, 2 km from the expedition campsite, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1066 & 1067</i> . | A 'walking gingers' (4) | Regular, but locally rare, especially in the east coast; other record is from Crocker Range. |
| 24. | <i>Etilingera pubescens</i> R.M. Smith | Herb, 1.7 m tall, base reddish, leaf sheath yellowish green, fruits dark red, half embedded in soil. Near Galas waterfall, on riverbank, open area, disturbed forest, lowland. <i>J.Gobilik et al. 1075</i> . | Stems red, inflorescence large, flowers yellow (1) | Common, especially in montane forest |
| 25. | <i>Etilingera rosamariae</i> A.D. Poulsen & Gobilik | Herb, 1.2 m tall, solitary individual, growing from trailing rhizome, each individual is about half a meter or more from one to another, inflorescence shoots out from the trailing rhizome, 4 cm from the base of the leafy shoot or at the middle of two shoots, flower bright red, labellum red with yellow smear on the throat. Junction of trail to Galas waterfall and hot spring, lowland primary forest. <i>J.Gobilik et al. 1073</i> . | Flowers are noticeable only during flowering season, or otherwise plain green (4) | Common, especially in montane forest |

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| 26. | <i>Etilingera rubromarginata</i>
A.D. Poulsen & J. Mood | Herb, 1 m tall, base white, leaf sheath light green with reddish dots. Trail to hot spring, on riverbank, open area, forest of superficial disturbance, lowland. <i>J.Gobilik et al. 1088</i> . Herb, 1 m tall, plain green, fruits green, bracts green with margin red. Trail to hot spring, riverbank, forest of superficial disturbance, lowland. <i>J.Gobilik et al. 1107</i> . | Flowers are noticeable during flowering season, but otherwise it is plain green (4 or 3) | Common |
| 27. | <i>Etilingera sessilantha</i> R.M. Smith | Herb, 0.7 m tall, upper leaf surface dull green, lower surface purplish on the edge. Trail to hot spring, on riverbank, forest of superficial disturbance, lowland. <i>J.Gobilik et al. 1103</i> . | Flowers are noticeable during flowering season, but otherwise it is just plain green (4) | Common |
| 28. | <i>Globba pendula</i>
Roxb. | Herb, 0.2–0.3 m tall, flowers yellow with brown dot on the labellum. Trail from Mt. Lucia to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1049</i> . | Flowers yellow (2) | Common |
| 29. | <i>Hornstedtia scyphifera</i> (Koenig) Steud. | Herb, 1.5 m tall, rhizome red, young stilt root red, inflorescence bracts green with white waxy, flowers red, labellum red, stigma pale white. Peak of Mt. Lucia, primary forest, semi lower montane; forest with strong lowland forest characteristics. <i>J.Gobilik et al. 1042</i> . | Forms a noticeable cluster, but does not grow very well in lowland (3 or 2) | Common, especially in montane forest |
| 30. | <i>Hornstedtia</i> sp. A | Herb, 1 m tall, leaf sheaths of young shoot dark purplish. Around Galas waterfall, on riverbank, forest with superficial disturbance, lowland. <i>J.Gobilik et al. 1081</i> . | Leaf sheaths of young shoots dark purplish (3) | Tawau Hills Park |
| 31. | <i>Hornstedtia tomentosa</i> (Blume) Bakh. f. | Herb, 1.6 m tall, inflorescence bracts dark purple, flowers yellow, labellum duck-beak shape. Trail from expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1092</i> (SAN? with spirit collection). Herb, 2 m tall, inflorescence bracts dark purplish, flowers yellowish orange, labellum duck-beak shape. Around Galas waterfall, on riverbank, inundated area, forest of superficial disturbance, lowland. <i>J.Gobilik et al. 1079</i> . | Flowers noticeable during flowering time, or otherwise just plain green (3) | Rare |

32. <i>Hedychium</i> sp. A	Herb, 0.4 m tall, base purple, upper leaf surface dark green, lower surface burgundy, inflorescence bracts green. On the trail near to Mt. Magdalena, lower montane primary forest. <i>J.Gobilik et al. 1058.</i>	Lower leaf surface purple, fruit flesh red (1 or 2)	Tawau Hills Park
33. <i>Plagiostachys albiflora</i> Ridl. (In Sabah, it has several forms.)	Herb, 0.3 m tall, leaf sheaths purplish, leaves dark green, slightly plicate, petiole long, fruits pale green (young) to dark green (mature). Trail from Mt. Lucia to Mt. Magdalena, third river, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1048.</i> Herb, 0.7 m tall, leaf sheaths purplish, leaves dark green, slightly plicate, petiole long. Trail from Mt. Lucia to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1047.</i> Herb, 0.9 m tall, leaf sheaths purplish, leaves dark green, slightly plicate, petiole long, fruits dark green. Trail from Mt. Lucia to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1053.</i> Herb, 0.7 m tall, leaf sheaths purplish, leaves dark green, petiole long, fruits dark green. Trail from Mt. Lucia to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1059.</i>	Inflorescence noticeable, fruits conspicuous, but just plain green outside of flowering and fruiting season (3 or 4)	Common
34. <i>Plagiostachys breviramosa</i> J. Cowley	Herb, c.0.6 m tall, inflorescence bracts papery, brown. Trail from Mt. Lucia to Mt. Magdalena, primary forest of prominent lower montane characteristics. <i>J.Gobilik et al. 1060.</i>	Inflorescence noticeable, fruits conspicuous, but the plant is just plain green outside of flowering and fruiting season (3 or 4)	Common, especially in the east coast
35. <i>Plagiostachys oblanceolata</i> J. Gobilik & A. Lamb	Herb, 0.1 m tall, inflorescence and flowers red all over, bracts partially dried. <i>Rentis</i> to Sg. Merotai, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1068.</i> Herb, 0.35 m tall, leaves dark green, inflorescence and flowers red. Ridge area after Mt. Lucia's peak, lowland primary forest. <i>J.Gobilik et al. 1041.</i>	Young leaves red, inflorescence noticeable, but just plain green outside of flowering season (3 or 4)	Rare; distribution is concentrated in Tawau; the other record is from Imbak Canyon Conservation Area

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| 36. | <i>Plagiostachys roseiflora</i> A. Julius & A. Takano | Herb, 0.6 m tall, green all over, inflorescence red all over, labellum red with orange smear on the throat. <i>Rentis</i> from expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1082</i> . Herb, c. 0.3 m tall, inflorescence red all over, labellum red with orange smear on the throat. <i>Rentis</i> from expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1089</i> . Herb, 0.5 m tall, inflorescence red all over, flowers red, labellum red with orange smear on the throat, fruits red. 500 m before the expedition campsite, lowland primary forest. <i>J.Gobilik et al. 1087</i> . Herb, 0.5–0.7 m tall, leaves and stem green all over, fruits red, calyx persistent, brownish. <i>Rentis</i> from the expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1083</i> . Herb, 0.7 m tall, plants green all over, inflorescence red, labellum red with orange smear. <i>Rentis</i> to Sg. Merotai, 500 m from the expedition campsite (2.3 km from Mt. Lucia's peak), lowland primary forest. <i>J.Gobilik et al. 1065</i> . Herb, 1.2 m tall, plants green all over, inflorescence bracts pinkish. Trail to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1050</i> . | Young leaves red, inflorescence noticeable, but just plain green outside of flowering season (3 or 4) | Rare |
| 37. | <i>Plagiostachys</i> sp. A | Herb, 1.5 m tall, plants dull green, very hairy, inflorescence bud pink. <i>Rentis</i> from expedition campsite to Sg. Tawau (2.3 km from the peak of Mt. Lucia), on riverbank, lowland primary forest. <i>J.Gobilik et al. 1097</i> . | Inflorescence noticeable, but just plain green outside of flowering season (3) | Rare; the other record is from Crocker Range |
| 38. | <i>Plagiostachys strobilifera</i> (Bak.) Ridl. | Herb, 2 m tall, plants all over green, fruits at the middle of the stem, globose, white. Trail to Mt. Magdalena, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1052</i> . | Young leaves red, inflorescence noticeable, but just plain green outside of flowering season (3 or 4) | Common |

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| 39. | <i>Zingiber flagelliforme</i>
Theilade & Mood | Herb, 0.2 m tall, inflorescence bracts pink, flower pale orange brown. <i>Rentis</i> from expedition campsite to Sg. Tawau (2.3 km from the peak of Mt. Lucia), on riverbank, lowland primary forest. <i>J.Gobilik et al. 1098</i> . Herb, 0.6 m tall, inflorescence bracts pale pink to pinkish red. Adjacent to expedition campsite, lowland primary forest with prominent montane characteristics. <i>J.Gobilik et al. 1070</i> . Herb, 2 m tall, slanting, trailing on the ground, producing bulbills, inflorescence bright orange (young). Trail to Mt. Lucia, 50 metres after the expedition campsite, lowland primary forest with prominent lower montane characteristics. <i>J.Gobilik et al. 1055</i> . | Inflorescence large and showy, pink (1) | Common, especially in the east coast |
| 40. | <i>Zingiber pseudopungens</i>
R.M. Smith | Herb, 1.2 m tall, inflorescence bracts pink, flower pale orange. Trail to hot spring, near to river, disturbed lowland forest. <i>J.Gobilik et al. 1104</i> . | Inflorescence large and showy, pink (1) | Common, especially in montane forest (Trusmadi Range & Crocker Range) |
| 41. | <i>Zingiber</i> cf. <i>gracile</i> Jack. | Herb, 1.7 m tall, inflorescence bracts orange yellowish, rhizome large, outside brownish, inside purplish. Trail to Mt. Lucia, 50 m after the expedition campsite, lowland primary forest of prominent montane characteristics. <i>J.Gobilik et al. 1069</i> . Similar to HI497 (Ibrahim, 1999) | Inflorescence large and showy, orange (1) | Rare |
| 42. | <i>Zingiber</i> sp. A | Herb, 0.7 m tall, base red, inflorescence dark pink all over including the peduncle, tip narrowly tapering. Along the trail to hot spring, before the first river, lowland primary forest. <i>J.Gobilik et al. 1074</i> . Herb, 0.3 m tall, inflorescence bracts pink, tip narrowly tapering. <i>Rentis</i> from expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1094</i> . | Inflorescence large and showy, dark pink (1) | Tawau Hills Park |

43.	<i>Zingiber</i> sp. B	Herb, 1.5 m tall, leaves and stem dark green, produces sweet smell when crushed, inflorescence bracts pink, flower cream white. <i>Rentis</i> from the expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1085.</i>	Inflorescence large and showy, pink (1)	Tawau Hills Park
44.	<i>Zingiber</i> sp. C	Herb, 2 m tall, inflorescence pink. Trail to Mt. Lucia, around 1 km before the expedition campsite, lowland primary forest. <i>J.Gobilik et al. 1071.</i>	Inflorescence large and showy, pink (1)	Tawau Hills Park
45.	<i>Zingiber vinosum</i> Theilade & Mood	Herb, 0.9 m tall, leaf sheath purplish green, upper leaf surface dark green, lower surface purple, inflorescence bracts purple with margin dark purple, flowers pale orange. <i>Rentis</i> from expedition campsite to Sg. Tawau, lowland primary forest. <i>J.Gobilik et al. 1100.</i>	Leaf sheaths reddish, lower leaf surface burgundy, inflorescence large and showy, burgundy (1)	Common, especially in the east coast
46.	<i>Zingiber viridiflavum</i> Theilade & Mood	Herb, 1.7 m tall, leaves and stem plain green, inflorescence bracts green with margin yellowish, flowers white cream. <i>Rentis</i> from expedition campsite to Sg. Tawau, on riverbank, lowland primary forest. <i>J.Gobilik et al. 1096.</i>	Inflorescence large and showy, bracts green, turning to orange during fruiting (1)	Common, especially in the east coast

Appendix 2. Records of gingers from the ginger trail at the ‘Lowland Garden’ in the Park.

No.	Species	Descriptions	Notes on Attractiveness (Group)	Notes on Distribution in Sabah
1.	<i>Alpinia aquatica</i> (Retz.) Rosc.	Herb, 0.7–1 m tall, leaves and stem green all over, leaves caudate, margin towards apex spiny, flowers white with purplish smear on labellum.	It grows in cluster, mass flowering and fruiting, flowers white (1)	Common, especially in coastal area
2.	<i>Alpinia ligulata</i> K. Schum.	Herb, 1–1.5 m tall, leaves and stem green all over, ligule 2–3 cm, papery, brittle. Collected as HI 473, 485 & 489 by H. Ibrahim (1999)	Inflorescence Dense inflorescence, but flowers are small (4)	Common, especially in the east coast

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| 3. | <i>Boesenbergia</i>
sp. B | Herb, c. 10 cm tall, leaf sheaths reddish, petiole 3–5 cm long, leaves green, midrib silvery. | Midrib silvery (2) | Tawau Hills Park |
| 4. | <i>Burbidgea</i> cf.
<i>schizocheila</i> Ridl. | Herb, c. 0.45–0.6 m tall, leaves and stem green all over, inflorescence bright yellow. Differing from HI463 (Ibrahim, 1999) by its much narrower leaves and yellow flowers. | Inflorescence bright yellow (1) | Common |
| 5. | <i>Etilingera</i>
<i>coccinea</i>
(Koenig) Sakai &
Nagamasu | Herb, 1.5–1.7 m tall, leaves and stem green all over, crushed leaves with bug smell, flowers red to pink, labellum side lobes yellow. | Flowers are conspicuous only during flowering season (4) | Widespread |
| 6. | <i>Etilingera</i> <i>elatior</i>
(Jack) R.M.
Smith | Herb, 1.5–2 m tall, leaves and stem light green all over, inflorescence bracts red to pink, peduncle 0.45–0.6 m long, green, flowers red, fruits round, red. | Prominent inflorescence, bracts red (1) | Widespread, widely cultivated |
| 7. | <i>Etilingera</i>
<i>fimbriobracteata</i>
Koenig | Herb, 1.5–1.7 m tall, leaf sheaths yellowish with red dots, inflorescence bracts red, flowers yellow with reddish anther, labellum short, round. | Flowers yellow, mass flowering (2) | Common |
| 8. | <i>Etilingera</i>
<i>megalocheilos</i>
(Griff.) A.D.
Poulsen | Herb, 1.5–2 m tall, leaves and stem green all over, inflorescence bracts red, flowers red, labellum elongated, side lobes absent, anther red | Flowers conspicuous, red, seasonal (4 or 3) | Common |
| 9. | <i>Etilingera</i>
<i>pyramidosphaera</i>
R.M. Smith | Herb, 1.5–2 m tall, leaves and stem light green all over, leaves wavy, lower surface green to purplish, inflorescence bracts green, peduncle 0.45–0.6 m long, flowers pink, fruits pyramid-shaped, green to yellowish | Leaves wavy, inflorescence prominent flowers red, fruits conspicuous, (1) | Common |
| 10. | <i>Etilingera</i> cf.
<i>velutina</i> A.D.
Poulsen | Herb, 1.5–1.7 m tall. Vegetatively very close to <i>E. velutina</i> ; its upper surface of petiole is reddish, which fits <i>E. velutina</i> ; inflorescence is not seen for comparison. | Flowers conspicuous only during flowering season (4 or 3) | Common, especially in montane forest. |
| 11. | <i>Geocharis</i>
<i>fursiformis</i> var.
<i>borneense</i> R.M.
Smith | Herb, 1–1.5 m tall, leaf sheaths dark purplish, white waxy, veins prominent | Flowers bright yellow (2) | Common |

12.	<i>Globba propinqua</i> Ridl.	Herb, 0.3–0.4 m tall, leaves and stem green all over, leaves green with purplish smear underneath, inflorescence bracts prominent, green, flowers bright yellow.	Flowers yellow (2)	Regular
13.	<i>Hedychium muluense</i> R.M.Smith	Herb, 0.3 m tall, leaves and stem green, inflorescence bracts green, flowers white, lateral staminodes yellowish, almost equal length to labellum.	Flowers white, seed arils red (2)	Rare
14.	<i>Hornstedtia</i> cf. <i>leonurus</i> (Koenig) Retz.	Herb, 1.7–1.8 m tall, leaves and stem green all over, inflorescence bracts green, flowers dark red with tips pink whitish	Flowers conspicuous only during flowering season (4 or 3)	Rare
15.	<i>Plagiostachys crocydocalyx</i> (Schum.) Burt & R.M. Smith	Herb, 2–2.3 m tall, leaves and stem green all over, inflorescence 0.3–0.45 m long, flowers white, fruits round, green.	Plant size large, inflorescence large, tillers growth robust (4 or 3).	Common
16.	<i>Zingiber</i> cf. <i>albiflorum</i> R.M. Smith	Herb, 1–1.5 m tall, green, inflorescence bracts white. Similar to HI 510 (Ibrahim, 1999)	Inflorescence bracts white (1 or 2)	Rare
