An assessment of orchids' diversity in Penang Hill, Penang, Malaysia after 115 years

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Abstract A comprehensive study on the orchid diversity in Penang Hill, Penang, Malaysia was conducted from 2004 to 2008 with the objective to evaluate the presence of orchid species listed by Curtis (J Strait Br R Asiat Soc 25:67–173, 1894) after more than 100 years. A total of 85 species were identified during this study, of which 52 are epiphytic or lithophytic and 33 are terrestrial orchids. This study identified 57 species or 64.8% were the same as those recorded by Curtis (1894), and 78 species or 66.1% of Turner's (Gardens' Bull Singap 47(2):599–620, 1995) checklist of 118 species for the state of Penang including 18 species which were not recorded by Curtis (1894) and the current study but are actually collected from Penang Hill. A comparison table of the current findings against Curtis (1894) and Turner (1995) is provided which shows only 56 species were the same in all three studies. The preferred account for comparison was Curtis' (1894) list as his report was specifically for the areas around Penang Island especially Penang Hill, Georgetown and Ayer Itam areas. Our study reveals that about 50% of Curtis' collection localities have been converted to residential areas and agricultural land, and this probably explains the decreasing numbers of species found in the current study especially for the terrestrial species as epiphytic species have better adaptation capabilities towards environmental

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changes. Seven species were identified as new records to Penang Hill as they were not recorded by Curtis (1894). None of the three species recorded as endemic to Penang by Turner (1995) was recollected during the current study, of which only *Zeuxine rupestris* was in Curtis' (1894) list. Overall, we concluded that Penang hill harbours at least 136 species of orchids of which 78 species or 57.4% were recollected in this study. This also indicates that this area is still suitable for orchid growth even though it is surrounded by rapid development and mass conversion of forested land into fruit orchards and residential area. The designation of Penang Hill as a Permanent Forest Reserve would better guarantee the survival of some orchid species unless human interventions and climatic changes occur.

Keywords Orchid · Diversity · Threat · Penang Hill · Malaysia

Introduction

Penang Hill or Bukit Bendera as it is known in Malay, is located in Penang Island. It consists of a few peaks, the Western Hill which is the highest peak of 833 m (2,723 ft) above sea level, Bukit Laksamana, Tiger Hill, Government Hill, and Flagstaff Hill, the second highest peak of 735 m (2,450 ft). This hill system is mainly made up of hilly granitic mass with most of the hills being more than 700 m high. It has a cooler climate with temperatures ranging from 20 to 27°C and a mean minimum temperature below 21°C. It is an ideal retreat place both for the locals as well as for foreign tourists.

Botanical studies have started ever since the British arrived in Penang, as early as in the 1790s. Many local plants were identified, and new plants from elsewhere were introduced and planted in Penang for commercial purposes. Many plant specimens were collected by foreign botanists and sent back to their respective countries as herbarium specimens and living collections (Burkill 1966).

In 1894, Curtis published an account on his own orchid collection in Penang which consisted of 90 species from 46 genera, in this historical publication 'A Catalogue of the Flowering Plants & Ferns Found Growing Wild in the Island of Penang'. Turner (1995), however, revised the specimens deposited in the Singapore Botanical Garden's Herbarium (SING), the Royal Botanic Gardens at Kew, England (KEW), and local herbaria in the Forest Research Institute of Malaysia in Kepong (KEP), University Malaya (KLU), Biology Department, Universiti Putra Malaysia (UPM) and Universiti Kebangsaan Malaysia (UKMB) and published a comprehensive vascular plant checklist for Malaya (Peninsular Malaysia). In the checklist, he listed 140 species of orchids with specific reference to Penang which included three endemic species, *Cheirostylis goldschmidtiana*, *Eria diluta*, and *Zeuxine rupestris*. Cheah (2005), however, listed 26 species of terrestrial and lithophytic orchids, and Loy (2005) listed 35 species of epiphytic orchids. The above findings including new data collected after 2005 are presented and discussed in this paper.

The Penang flora is indeed very important as they are the remnants of the large forest of Peninsular Malaysia that is still surviving on this small island. Many of the island's previously common plants are now uncommon and rare due to human activities. For instance, the slipper orchid, *Paphiopedilum callosum* var. *sublaeve* which was wrongly identified as *Paphiopedilum barbatum* by Khor et al. (1991) and a species which used to be common in Penang, is currently becoming rare due to over-collection and habitat destruction. *P. barbatum* was never collected in Penang even though it was a widespread species. This confusion maybe due to the fact that Curtis (1894) listed *Cypripedium*

barbatum as one of the species, but this is a synonym of *P. callosum* var. *sublaeve* and not a basionym for *P. barbatum*.

Materials and methods

Five field observations and botanical collection trips were carried out from 2004 to 2008 along 18 forest trails: Cendana Hill Trail, Trail 5, Lily Pond, Mount Olivia Trail, Waterfall Trail, Summit Road, Government Hill Trail, Viaduct Road, South View Road, Moniot Road West, Moniot Road East, Path E, Upper Tunnel Road West, Upper Tunnel Road East, Lower Tunnel Road, Jeep Track, Middle Station and Western Hill Trail. The specimens were collected as living collections for those non-flowering materials and as herbarium specimens for both the non-flowering and flowering materials. The living specimens were transplanted in the greenhouse in Universiti Putra Malaysia for *ex situ* conservation and identification once they flowered. Flowered materials were then preserved as herbarium specimens and the flowers as spirit collections. All macro morphological characters, such as vegetative and floral structures, were observed and recorded in the field and also at the green house. The herbarium specimens were processed according to the standard herbarium specimen preparation techniques as outlined by Bridson and Forman (1989). Specimens were identified using the characters described and the identification keys in Holtum (1957), Seidenfaden and Wood (1992), and Comber (1990, 2001). Scientific names adopted here are those accepted by the latest Kew World Checklist of Selected Plant Families accessed via the web. All the herbarium specimens collected and studied were kept in the Herbarium of the Biology Department at the Faculty of Science, Universiti Putra Malaysia (UPM). Specimens in herbaria locally and abroad were also studied, especially those at the Singapore Botanical Garden (SING), the Royal Botanic Gardens Kew Herbarium (K), University Malaya (KLU), FRIM (KEP), and Universiti Kebangsaan Malaysia (UKMB) for further verification.

Results and discussion

A total of eighty five orchid species from 61 genera were collected during the period of study, of which 52 are epiphytic or lithophytic and thirty three are terrestrial. Seven species were identified as new records for the Penang Hill. The seven species are *Bulbophyllum biflorum*, *Coelogyne septemcostata*, *Cymbidium haematodes*, *Dendrobium convexa*, *Lepidogyne longifolia*, *Liparis barbata* and *Thrixspermum duplocallosum*. *B. biflorum* was previously recorded only from Pahang and Selangor by Turner (1995) but currently is known to be widespread within Malaysia. *C. septemcostata* and *L. longifolia* was previously only recorded as lowland forest species in Pahang and Johore. *C. haematodes*, however, was only known from Pulau Langkawi. *D. convexa* was previously found in Pontian, Johore and Ulu Kali, Selangor. *L. barbata* was previously documented in Perak, Tioman Island and Johore. Besides the new records, there were also some species collected which are common to Penang but not to Peninsular Malaysia, except for certain localities, such as *Acriopsis indica*, *Campanulorchis leiophylla* and *Hetaeria oblongifolia*.

Eria, *Dendrobium* and *Bulbophyllum* were among the genera with the most species found in this study site. The Western Hill exhibited a high diversity of orchid as the highest number of orchids was recorded from the Western Hill Trail. This correlates with the elevation of the land as the Western Hill is the highest peak in the Penang Hill system. The higher elevation provides a suitable environment for the orchids to thrive as the

temperature is lower and the humidity is higher. The Moniot Road East, Moniot Road West, Government Hill Trail and Cendana Hill Trail were also among the selected trails where more than six species were collected. The other trails visited, however, exhibited a lower diversity. This might be due to the rapid development of the town and some recreational areas which affected orchid growth.

Most of the orchid specimens collected are epiphytic and lithophytic. There were also several terrestrials. This is because of the limited soils or humus to support plant growth as there are numerous huge granite borders and outcrops in this area. Hence, most of the orchids are growing abundantly on tree trunks and rocks layered with plant sediments or humus. Some variations of characters, such as colour of flowers, leave sizes and overall plant size differ among the collected specimens and the cited specimens in the references. This phenomenon might possibly be due to environmental and genetic factors which should be further explored. Besides that, most of the specimens collected were from the higher altitudes, at 700 m upwards. In addition, the abundance of species was low as most of the species were observed as individual plants or small populations of 2–3 plants.

The current orchid diversity in Penang is listed in Table 1, which is a compilation of species recorded by Curtis (1894) and Turner (1995) and results from the current study. A total of 136 species were found in Penang Hill. This study recorded an additional seven species as new records to Penang. The diversity when compared to those reported by Curtis (1894) revealed that only 21 species listed by him were not collected during the current study. This could be explained as more than 70% of the species collected are epiphytic orchids and they have better adaptations to environmental changes when compared to the terrestrials. Apart from that, Curtis' (1894) collections that were not collected during the current study were actually obtained from areas that are now residential and fruit tree orchards. The conversion of forested areas for development is an irreversible destruction which could wipe out species from any kinds of habitat.

Turner (1995) listed a total of 118 species of orchids recorded for the state of Penang which includes the 18 species not recorded by Curtis (1894) or this current study but were collected from Penang Hill as recorded by Seidenfaden and Wood (1992). He also listed three species as endemic to Penang, namely *Cheirostylis goldschmidtiana*, *E. diluta* and *Zeuxine rupestris*. *C. goldschmidtiana* and *E. diluta* were both not recorded by Curtis (1894) and this study but they were recorded by Seidenfaden and Wood (1992), which included the locality of the specimens studied. For *E. diluta*, there are two specimens belonging to this species in the Kew Herbarium (K) of which the type was actually collected from Kedah Peak (Gunung Jerai), Kedah. Therefore, it should not be listed as endemic to Penang as claimed by Turner (1995). The second collection was from Pantai Aceh, Penang, which is not part of the Penang Hill complex. *C. goldschmidtiana* was recorded in Penang based on a single record collected in 1912 at Bukit Bendera (Penang Hill) and was never collected again from here (Seidenfaden and Wood 1992). However, the same species was recently (January, 2010) collected in Baling, Kedah by Rogier van Vugt and the photographs were published online in the Website of the Swiss Orchid Foundation of the Herbarium Jany Renz which is operating under the patronage of the University of Basel, Switzerland (accessed on 12 May, 2011). With this discovery, *C. goldschmidtiana* is no longer endemic to Penang but still an endemic to Peninsular Malaysia. Nevertheless, it is worthwhile to further search for this species around Penang Hill, otherwise considered extinct from this location. *Z. rupestris*, however, was recorded by Curtis, which was based on a single record from Bukit Bendera (Penang Hill) at 700 m altitude (Seidenfaden and Wood 1992) but was not found in the present study. Unfavourable environmental condition (currently higher temperature and frequent prolonged

Table 1 Comparison of orchid species found in Penang Hill during the current study with those listed by Curtis (1894)

No.	Species	Curtis (1894)	Turner (1995)	Current study
1.	<i>Acampe rigida</i>	✓	✓	
2.	<i>Acanthephippium javanicum</i>		✓	
3.	<i>Acropsis indica</i>	✓	✓	✓
4.	<i>Acropsis liliifolia</i>	✓	✓	✓
5.	<i>Aerides odorata</i>	✓	✓	✓
6.	<i>Agrostophyllum majus</i>	✓	✓	✓
7.	<i>Agrostophyllum stipulatum</i>	✓	✓	✓
8.	<i>Ainia penangiana</i>	✓	✓	✓
9.	<i>Anoectochilus albolineatus</i>	✓	✓	✓
10.	<i>Anoectochilus brevistylus</i>	✓	✓	
11.	<i>Apostasia wallichii</i>	✓	✓	✓
12.	<i>Appendicula anceps</i>	✓	✓	✓
13.	<i>Appendicula pendula</i>	✓	✓	
14.	<i>Arundina graminifolia</i>		✓	✓
15.	<i>Bromheadia finlaysoniana</i>	✓	✓	✓
16.	<i>Bromheadia truncata</i>		✓	✓
17.	<i>Bulbophyllum angustifolium</i>	✓	✓	
18.	<i>Bulbophyllum biflorum**</i>			✓
19.	<i>Bulbophyllum bisetum</i>	✓	✓	
20.	<i>Bulbophyllum blepharistes</i>	✓	✓	
21.	<i>Bulbophyllum corolliferum</i>		✓	
22.	<i>Bulbophyllum haniffii</i>		✓	✓
23.	<i>Bulbophyllum hirtulum</i>		✓	
24.	<i>Bulbophyllum inunctum</i>		✓	
25.	<i>Bulbophyllum lasianthum</i>		✓	✓
26.	<i>Bulbophyllum leptosepalum</i>	✓	✓	✓
27.	<i>Bulbophyllum medusae</i>	✓	✓	✓
28.	<i>Bulbophyllum membraneum</i>		✓	✓
29.	<i>Bulbophyllum obtusum</i>		✓	✓
30.	<i>Bulbophyllum pileatum</i>	✓	✓	✓
31.	<i>Bulbophyllum pulchellum</i>	✓	✓	
32.	<i>Bulbophyllum uniflorum</i>		✓	✓
33.	<i>Bulbophyllum vaginatum</i>	✓	✓	✓
34.	<i>Calanthe pulchra</i>	✓	✓	✓
35.	<i>Callostylis pulchella</i>	✓	✓	✓
36.	<i>Campanulorchis leiophylla</i>	✓	✓	✓
37.	<i>Campanulorchis pellipes</i>	✓	✓	✓
38.	<i>Ceratostylis pendula</i>		✓	✓
39.	<i>Cheirostylis goldschmidtiana*</i>		✓	
40.	<i>Cheirostylis montana</i>		✓	
41.	<i>Cheirostylis pusilla</i>		✓	
42.	<i>Claderia viridiflora</i>	✓	✓	✓
43.	<i>Cleistoma scortechinii</i>	✓	✓	

Table 1 continued

No.	Species	Curtis (1894)	Turner (1995)	Current study
44.	<i>Cleistoma subulatum</i>	✓	✓	
45.	<i>Coelogyne cumingii</i>	✓	✓	
46.	<i>Coelogyne mayeriana</i>		✓	✓
47.	<i>Coelogyne rochussenii</i>	✓	✓	✓
48.	<i>Coelogyne septemcostata</i> **			✓
49.	<i>Coelogyne trinervis</i>		✓	✓
50.	<i>Coelogyne velutina</i>	✓		✓
51.	<i>Corymborkis veratrifolia</i>	✓	✓	✓
52.	<i>Crepidium calophyllum</i>		✓	
53.	<i>Cryptostylis arachnites</i>	✓	✓	✓
54.	<i>Cymbidium finlaysonianum</i>	✓	✓	✓
55.	<i>Cymbidium haematodes</i> **			✓
56.	<i>Dendrobium aloifolium</i>	✓	✓	✓
57.	<i>Dendrobium anosmum</i>		✓	✓
58.	<i>Dendrobium bancana</i>		✓	✓
59.	<i>Dendrobium bifarium</i>	✓	✓	✓
60.	<i>Dendrobium concinnum</i>		✓	✓
61.	<i>Dendrobium convexum</i> **			✓
62.	<i>Dendrobium crumenatum</i>	✓	✓	✓
63.	<i>Dendrobium excavatum</i>		✓	
64.	<i>Dendrobium farmeri</i>		✓	
65.	<i>Dendrobium grande</i>	✓	✓	✓
66.	<i>Dendrobium leonis</i>	✓	✓	✓
67.	<i>Dendrobium metrium</i>		✓	
68.	<i>Dendrobium pachyphyllum</i>	✓	✓	
69.	<i>Dendrobium plicatile</i>		✓	✓
70.	<i>Dendrobium sanguinolentum</i>	✓	✓	✓
71.	<i>Dendrobium secundum</i>	✓	✓	✓
72.	<i>Dendrobium singaporense</i>		✓	
73.	<i>Dendrobium sinuatum</i>	✓	✓	✓
74.	<i>Dendrobium subulatum</i>	✓	✓	
75.	<i>Dendrobium villosulum</i>	✓	✓	
76.	<i>Dendrobium xantholeucum</i>	✓	✓	
77.	<i>Dienia ophrydis</i>	✓	✓	✓
78.	<i>Dipodium pictum</i>		✓	✓
79.	<i>Dipodium scandens</i>		✓	✓
80.	<i>Eria neglecta</i>	✓	✓	✓
81.	<i>Eria nutans</i>	✓	✓	✓
82.	<i>Eria ornata</i>		✓	✓
83.	<i>Erythrorchis altissima</i>	✓	✓	
84.	<i>Eulophia andamanensis</i>		✓	✓
85.	<i>Eulophia spectabilis</i>	✓	✓	✓
86.	<i>Galeola nudifolia</i>	✓	✓	

Table 1 continued

No.	Species	Curtis (1894)	Turner (1995)	Current study
87.	<i>Geodorum citrinum</i>	✓	✓	✓
88.	<i>Geodorum densiflorum</i>	✓	✓	
89.	<i>Goodyera viridiflora</i>		✓	✓
90.	<i>Grammatophyllum speciosum</i>	✓	✓	✓
91.	<i>Habenaria rhodocheila</i>		✓	✓
92.	<i>Hetaeria nitida</i>		✓	
93.	<i>Hetaeria obliqua</i>	✓	✓	
94.	<i>Hetaeria oblongifolia</i>		✓	✓
95.	<i>Lepidogyne longifolia**</i>			✓
96.	<i>Liparis barbata**</i>			✓
97.	<i>Liparis maingayi</i>	✓	✓	✓
98.	<i>Ludisia discolor</i>	✓	✓	
99.	<i>Luisia curtisii</i>	✓	✓	
100.	<i>Macodes petola</i>		✓	
101.	<i>Nervilia plicata</i>		✓	
102.	<i>Nervilia punctata</i>	✓	✓	
103.	<i>Neuwiedia veratrifolia</i>	✓	✓	✓
104.	<i>Neuwiedia zollingeri</i> var. <i>singaporeana</i>	✓	✓	
105.	<i>Oberonia lycopodioides</i>	✓	✓	✓
106.	<i>Oberonia pumilio</i>		✓	
107.	<i>Odontochilus uniflorus</i>	✓	✓	
108.	<i>Paphiopedilum callosum</i> var. <i>sublaeve</i>	✓	✓	
109.	<i>Peristylus lacertifer</i>	✓	✓	
110.	<i>Pinalia maingayi</i>	✓	✓	
111.	<i>Podochilus tenuis</i>	✓	✓	✓
112.	<i>Polystachya concreta</i>	✓	✓	✓
113.	<i>Renanthera elongata</i>	✓	✓	✓
114.	<i>Robiquetia spathulata</i>	✓	✓	✓
115.	<i>Spathoglottis plicata</i>	✓	✓	✓
116.	<i>Stichorkis elegans</i>	✓	✓	✓
117.	<i>Stichorkis viridiflora</i>	✓	✓	
118.	<i>Taeniophyllum pusillum</i>	✓	✓	
119.	<i>Tainia maingayi</i>	✓	✓	
120.	<i>Tainia wrayana</i>		✓	✓
121.	<i>Thelasis micrantha</i>	✓	✓	
122.	<i>Thrixspermum amplexicaule</i>	✓	✓	✓
123.	<i>Thrixspermum centipeda</i>	✓	✓	✓
124.	<i>Thrixspermum duplocallosum**</i>			✓
125.	<i>Thrixspermum trichoglottis</i>	✓	✓	✓
126.	<i>Thrixspermum calceolus</i>	✓	✓	✓
127.	<i>Trichoglottis cirrhifera</i>	✓	✓	✓
128.	<i>Trichotosia ferox</i>	✓	✓	✓
129.	<i>Trichotosia gracilis</i>	✓	✓	✓

Table 1 continued

No.	Species	Curtis (1894)	Turner (1995)	Current study
130.	<i>Trichotosia rotundifolia</i>		✓	
131.	<i>Trichotosia velutina</i>	✓	✓	
132.	<i>Vanilla griffithii</i>	✓	✓	✓
133.	<i>Ventricularia tenuicaulis</i>	✓	✓	✓
134.	<i>Zeuxine affinis</i>	✓	✓	✓
135.	<i>Zeuxine parvifolia</i>		✓	
136.	<i>Zeuxine rupestris</i> *	✓	✓	
Total		89	118	86

✓, present

* Endemic to Penang as reported by Turner (1995)

** New record to Penang Hill

draught) was suggested for the reason it was not found during this study, the scenario better explained by the discovery of unhealthy small plants in a small population of another species, *Zeuxine affinis* at Government Hill which is the highest peak of Penang Hill system. *Coelogyne velutina* a new species described by de Vogel in 1992 based on specimens collected by Maingay from Government Hill was the only species not recorded by Turner (1995), but this species was recollected from the same locality in this study. *Bulbophyllum bisetum* listed by Curtis (1894) might be of wrong identification as the distribution of this species is from East Himalaya to Northern Thailand and was never mention in Seidenfaden and Wood (1992) and Turner (1995).

The comparison between the current study and that of Curtis (1894) recorded almost the same number of species 88 (Curtis, 1894) and 85 (current study) with 57 (57%) species overlapped. The differences between the two lists could be due to species being overlooked and also by natural changes in orchid flora as orchids spread easily provided the environment is ideal for its germination and growth. In a nut shell, the orchid flora of Penang Hill is more or less intact, in spite of humans messing around in that area for more than a century. This is however, some light of hope for people involved in orchid conservation that even forests altered to some extent by human activities can retain most of their orchid flora.

The state government's decision to gazette the Penang Hill system as a Permanent Forest Reserve signifies their support towards conservation of the rich and unique biodiversity represented in this small pristine forest. At least Penang Hill could stand tall for as long as the world exists together with the natural treasures it houses including the ever adorable orchids, unless climatic changes and earth destruction occur. The previous record of *C. goldschmidtiana*, a rare and endemic species for Penang Hill and Baling, Kedah and the once presence *Z. rupestris* a narrowly endemic species to Penang Hill could also further justify and strengthen the grounds of conserving Penang Hill. Table 1 shows a comparison of the orchids found during this study with those listed by Curtis (1894) and Turner (1995). Figure 1 shows some of the beautiful orchids found during this study.

Conclusion

Penang Hill exhibits a great diversity of orchids relative to the small land area covered during this study. The 61 genera and 85 species portrayed an exceptionally rich orchid flora

Fig. 1 Penang orchids species and new records*. **a** *Lepidogyne longifolia**, **b** *Liparis barbata**, **c** *Bromheadia finlaysoniana*, **d** *Dendrobium convexa**, **e** *Arundina graminifolia*, **f** *Callostylis pulchella*, **g** *Cymbidium haematodes**

found in the 18 trails in Penang Hill system. Seven new records are added to the orchid checklist for Penang. Overall, Penang Hill is still suitable for orchid growth as the area is now being designated as a Permanent Forest Reserve and the survival of some orchid species are better guaranteed unless human intervention and climatic changes were to occur. Flagship species like *Paphiopedilum callosum* var. *sublaeve* (Slipper orchid) and once widely distributed *Grammatophyllum speciosum* (Tiger orchid) are examples of Penang indigenous species which are threatened in the wild and conservation measures should be introduced to safeguard their existence. The two species endemic to Peninsular

Malaysia namely *C. goldschmidtiana* and *Z. rupestris* which were previously recorded from Penang Hill should be further investigated to determined their true status in the wild.

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