
Research Article

A Species Checklist of Wild Orchids in Selected Sites in Kadamaian, Kota Belud, Sabah

Edward Entalai Besi¹, Dome Nikong², Muhamad Ikhwanuddin Mat Esa¹, Ahmad Asnawi Mus³, Heira Vanessa Nelson³, Nurul Najwa Mohamad³, Roslin Ombokou⁵, Nor Azizun Rusdi³, Devina David⁴, Zaleha Abdul Aziz⁵, Rusea Go^{1*}

¹Department of Biology, Faculty of Science, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

²No.5, Bangunan PMINT, Kg Sungai Tong, 21500 Setiu, Terengganu, Malaysia

³Unit for Orchid Studies, Institute for Tropical Biology and Conservation, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia

⁴Faculty of Sustainable Agriculture, Universiti Malaysia Sabah, 93509, Sandakan, Sabah, Malaysia

⁵Faculty of Science and Natural Resources, Universiti Malaysia Sabah, 88400 Kota Kinabalu, Sabah, Malaysia

*Corresponding author: rusea@upm.edu.my

Abstract

A brief orchid diversity study was conducted from 14th to 19th October 2019 in Kadamaian, located northwest of Kinabalu area, through a scientific geographic expedition. A convenience sampling method was employed with only the flowering individuals collected and preserved as herbarium specimens. A total of 58 species and 32 genera were identified during the field visits to the Mount Nopungguk, Melangkap Noriou, Ulu Sungai Melawa, and basecamp site. The finding comprises of 43 epiphytes, 13 terrestrials, and two mycoheterotrophs. *Appendicula congesta*, *Bulbophyllum disjunctum*, *Dendrobium kiauense*, and *Goodyera rostellata* are species endemic to Borneo found during the expedition along with *Crepidium multiflorum*, a hyper-endemic species to Kinabalu area. Several rare species which narrowly distributed to primary forest habitat were discovered, including jewel orchids; *Cystorchis variegata* var. *variegata* and *Anoectochilus geniculatus*, and two mycoheterotrophs; *Aphyllorchis pallida* and *Lecanorchis multiflora* var. *multiflora*.

Keywords: Borneo, Kinabalu area, Orchidaceae

Introduction

Kadamaian is a township or *mukim*, situated immediately to the northwest of Kinabalu Park in the west coast of Sabah. It is located within the Kota Belud district, and 88.3km from Kota Kinabalu, the capital of Sabah. The name 'Kadamaian' is taken from river found within the area vicinity; Kadamaian river. The highest peak in Kadamaian is Mount Nopungguk, with a height of 1,430m above sea level. Falls within the Kinabalu Park, a World Heritage Site,

Kadamaian is blessed with different forest types, which are lowland mixed dipterocarp forest, upland mixed dipterocarp forest, and lower montane forest. Due to its richness and abundance of biodiversity, a lot of recreation activities were initiated by locals such as river rafting, homestays, and hiking spots. The prominent Kinabalu Park has been set aside for the conservation and protection of the richest yet endangered plant community (Phillips, 1988; van der Ent, 2013).

Orchidaceae is one of the largest and most diverse families of flowering plants, comprising of 736 genera worldwide with around 27,000 species (Chase et al., 2015). The family is widely distributed in a variety of terrestrial ecosystems especially in the tropics, although it is absent from polar and desert areas (Romero, 1996). Borneo alone, is indeed rich with orchids, having 2,500 to 3,000 species, which is equivalent to 10% of the world's orchids and 75% of the Malesian orchid flora (Lamb, 1991). Of these, 30%-40% are thought to be endemic to Borneo (Chan et al., 1994). The forests of Kinabalu alone have over 1,200 species of wild orchids (Phillips, 1988).

To the best of our knowledge, the first published list of Bornean orchids was by Ridley in 1896 (Wood & Cribb, 1994). The author described 49 new species and recorded 224 species in 62 genera. The list was then updated in 1942 by Masamune (Wood & Cribb, 1994), in which the number was increased to 1,203 species in 99 genera. After that, an account by Wood & Cribb (1994) lists over 1,400 species in 149 genera in Borneo. Following publication of the 1993 orchid volume, Wood et al. (1993), an extensive compilation of the orchids of Mount Kinabalu became available, Wood et al. (2011), lists 866 taxa in 134 genera of orchids.

Since then, a number of studies were conducted to further profile the orchid diversity around Sabah. Most notably within the Crocker Range National Park (Majit et al., 2014), Kinabalu Park (Majit et al., 2014), and gazetted conservation areas such as Danum Valley (O'Malley, 2009), Imbak Canyon (Tsukaya et al., 2013), and Maliau Basin (Suetsugu et al., 2018). One recent study by Juiling et al. (2020) conducted an IUCN Red List assessment on 136 endemic species to Sabah, including in the Kinabalu and Crocker Range parks. So far, there is no known study on wild orchids documented for the Kadamaian area. Nevertheless, we hypothesized a high abundance of orchids could be present in the Kadamaian area given that the area is made of more than one type of forest and located within the biodiverse-mountain range. Moreover, the Bornean highland area possesses a wealth of wild orchids (Wood & Cribb, 1994; Beaman et al., 2001;

Majit et al., 2014; Besi et al., 2020). Orchids habitat specificity (Fay & Chase, 2009; Schödelbauerová et al., 2009) combined with the small populations exhibited by most species and narrow-pattern distribution (Chung et al., 2005; Rodrigoues & Kumar, 2009) makes them vulnerable to the threats of habitat loss and degradation (Coates & Dixon, 2007; Swarts & Dixon, 2009). In the last four decades, Sabah has lost 39.5% of its forest cover (Gaveau et al., 2014). Moreover, over-collection for ornamental and medicinal usage has become another significant threat to the survival of Orchidaceae (Hágsater & Dumont, 1996; Koopowitz et al., 2003).

As a part of conservation efforts to preserve Sabah's nature heritage, a scientific expedition was conducted, and aimed to record the diversity, composition and distribution of wild orchids in selected sites in the Kadamaian area. Here we report the preliminary finding.

Materials and Methods

Study site

A botanical convenience sampling was carried out from 14th to 19th October, 2019 in lowland to lower montane dipterocarp forests of Kadamaian, Sabah, Malaysia. Due to the limited time available, only four selected sites were studied including the basecamp area (Table 1, Figure 1 and Figure 2).

Table 1. Selected study sites

Sites	Vegetation types	Coordinates		Elev. (m)	Total distance (km)
		Labels in Fig. 1B	Latitudes and longitudes		
Nopungguk	Lower montane forest	1	N 06° 9' 7.8114", E 116° 18' 13.752"	245	ca. 6
		2	N 06° 11' 13.3", E 116° 30' 47.8"	1,419	
		3	N 06° 11' 46.7", E 116° 30' 48.8"	885	
		4	N 06° 11' 55.1", E 116° 30' 45.0"	849	
		5	N 06° 12' 25.6", E 116° 30' 34.1"	471	
Melangkap Noriou	Riparian forest	6	N 06° 11' 13.3", E 116° 29' 30.6"	513	ca. 2
		7	N 05° 50' 80.7", E 118° 07' 57.6"	631	
Hill near basecamp	Forest ridge	8	N 06° 12' 30.3", E 116° 31' 14.4"	875	ca. 1
Ulu Sungai Melawa	Mixed hill dipterocarp forest	9	N 06° 12' 15.0", E 116° 31' 20.9"	933	ca. 1

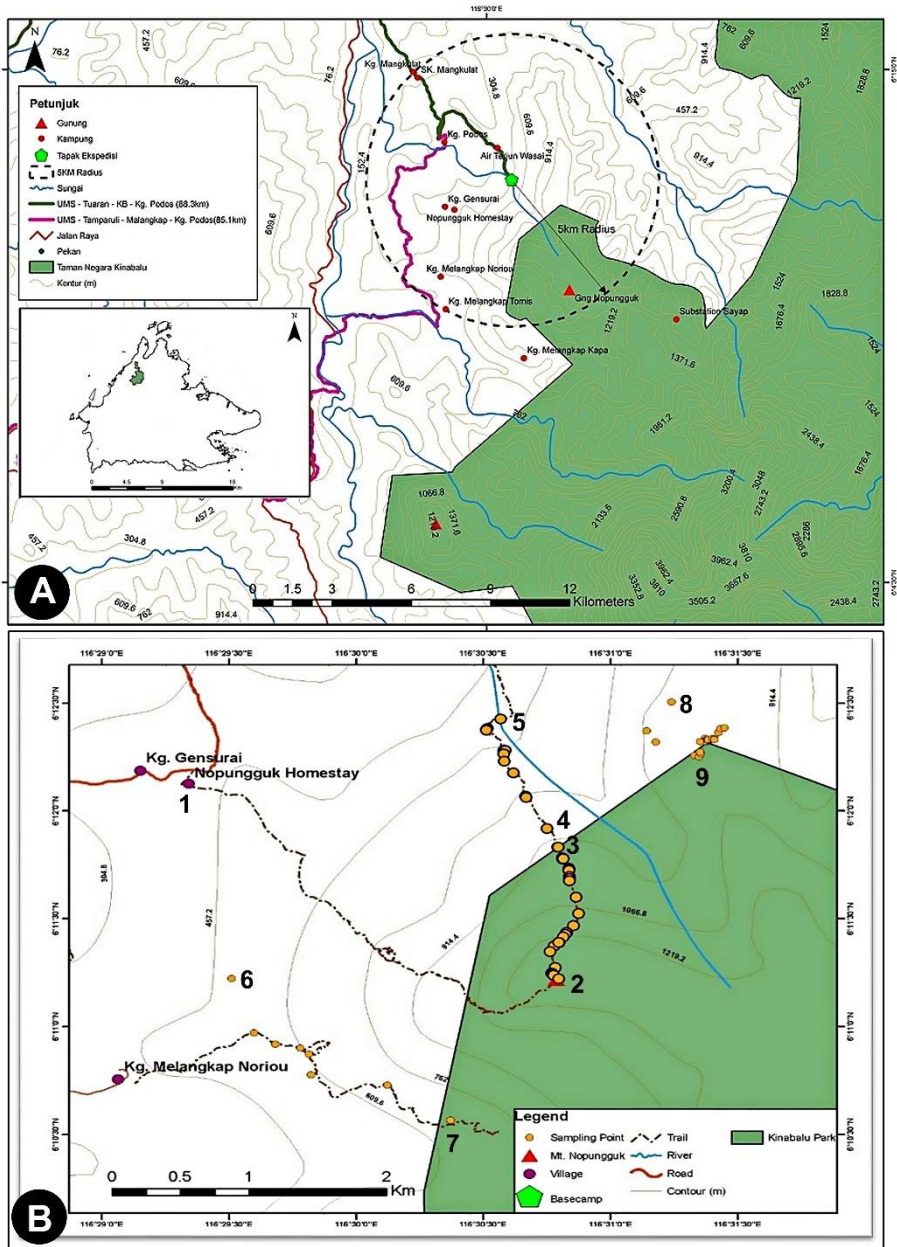


Figure 1. Kadamaian, Kota Belud District in Sabah (A) and locations of the study plots (B).

The sites were selected based on the vegetation type. The sampling was done along the existing and off-road four-wheel trails within a width of 10m to the left and 10m to right. Nopungguk is a relatively undisturbed lower montane forest. It is characterized by a cool and dim environment. There are two major trails, Podos-Nopungguk and Nopungguk-Gensurai. We climbed to the peak via Podos-Nopungguk trail and headed back via Nopungguk-Gensurai trail. As we travelled to the higher elevation area, the tree crowns were thicker and the surrounding atmosphere was dimmer and cooler. The ground was covered with leaf litter, protecting the substrate from disturbance. The upper trail was steep and quite narrow banked by cliffs at both sides. The Melangkap Noriou trail is majorly made of a riverine (riparian) forest. The area is a commonly visited recreation site. As we walked through the trail, we passed a secondary forest and rubber plantation, and then we entered a deeply shaded riparian forest that led us to the cascading waterfall of Kuminangkad. The Ulu Sungai Melawa is a hill forest connected to a four-wheel off-road track and forest ridge situated just above the basecamp.

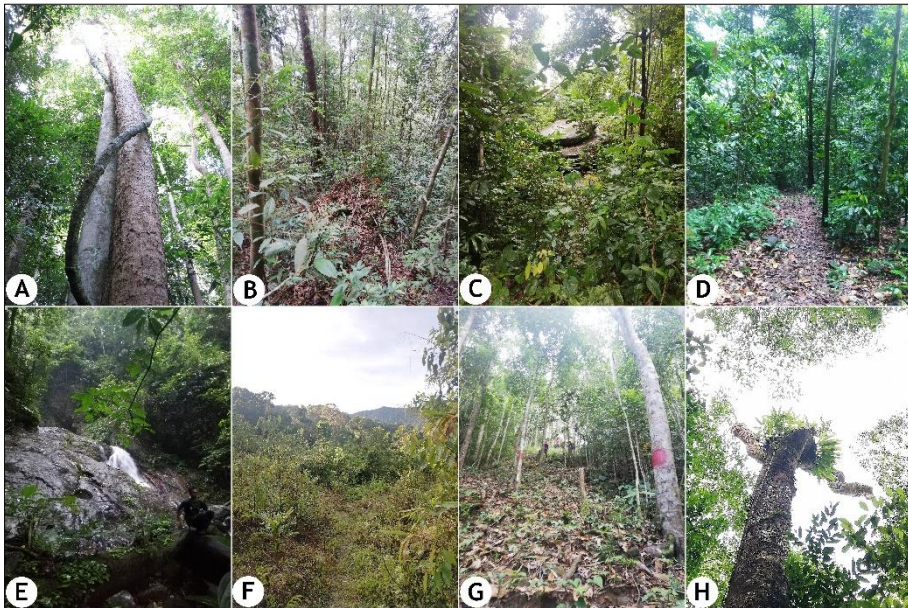


Figure 2. Study sites in Kadamaian: A) an emergent tree in Nopungguk trail; B) inland vegetation at the upper area of Nopungguk trail; C) Mirolian Stone (Batu Besar Bertingkat) in the Nopungguk trail; D) riverine trail in Melangkap Noriou; E) Kuminangkad waterfall at the end of Melangkap Noriou trail; F) forest ridge in Ulu Sungai Melawa; G) disturbed hill forest near basecamp; H) a dying tree accumulates epiphytic orchids in the hill forest of Ulu Sungai Melawa.

Sampling and specimen processing

Each site was only visited once during this preliminary study. One individual of the flowering specimens were collected and ripped or dug out properly by ensuring that the whole plant was extracted, including its root. The specimens were preserved using standard herbarium technique after Bridson & Forman (2000) and deposited in the herbarium of Institute for Tropical Biology and Conservation (ITBC), Universiti Malaysia Sabah (UMS). The non-flowering ones were not collected during the expedition following the restriction employed by the managing committee. All orchids encountered, either flowering or non-flowering, were photographed and important notes on their habit and morphology were recorded in a notebook.

The collected orchids were identified into their respective taxa based on their morphological characters and habits. Some identifications were done in the field and made possible based on photographs. Reliable references were used in the identification and classification processes such as Seidenfaden & Wood (1992), Wood (1997), Beaman et al. (2001), Comber (2001), and Wood (2003).

We also studied some of the digitalized herbarium specimens deposited in the international databases such as Harvard University Herbaria & Libraries (AMES) (https://kiki.huh.harvard.edu/databases/specimen_index.html), Swiss Orchid Foundation (SOF) (<https://orchid.unibas.ch/index.php/en/>), National Herbarium of the Netherlands (NHN) accessed through Browse Dutch Natural History Collections: BioPortal (Naturalis) (<http://bioportal.naturalis.nl/>), and also Kew World Checklist of Selected Plant Families (WCSP) (Govaerts et al., 2020). The information on the current distribution status was retrieved from published checklists by Wood et al. (1993), Wood & Cribb (1994), and Beaman et al. (2001); and the online databases as mentioned above.

Results and Discussion

A total of 58 species and 32 genera were identified during a brief visit to the Mount Nopungguk, Melangkap Noriou, Ulu Sungai Melawa, and basecamp sites of the 2019 Kadamaian Scientific expedition. Only 23 orchids were identified into their respective taxa, with the remaining only identified to their genera level or closest affinity as the floral structure was lacking upon assisting the identification. From the total orchids collected during the expedition, only 30% were flowering and fruiting, presumably due to the non-flowering period for orchids in the area. Some orchids were found with seed pods or dehisced seed pods signalling that we missed the flowering season during the expedition. Our

finding consists of 43 epiphytes, 13 terrestrials, and two mycoheterotrophs (Figure 3), and of these, 52 species are Epidendroideae, four are Orchidoideae, and one each for Apostasioideae and Vanilloideae (Figure 4). *Bulbophyllum*, *Coelogyne* and *Dendrobium* are the most abundant genera (Figure 5).

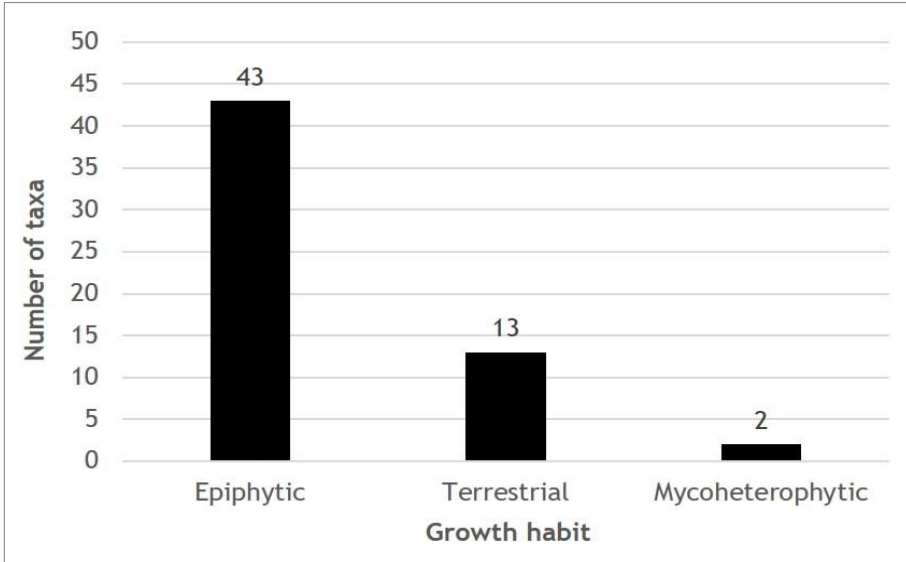


Figure 3. Number of orchid species with different types of growth habits in Kadamaian.

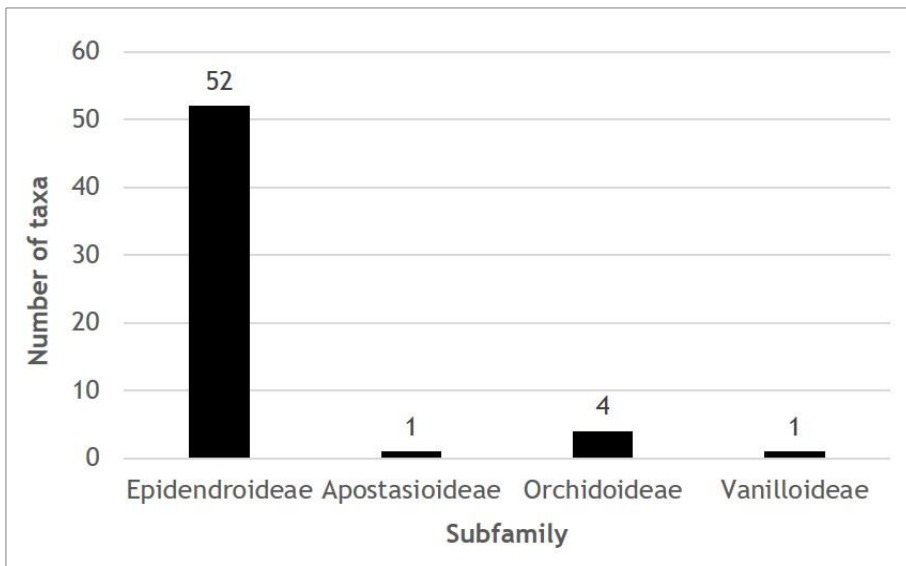


Figure 4. Number of orchid species from different subfamilies found in Kadamaian.

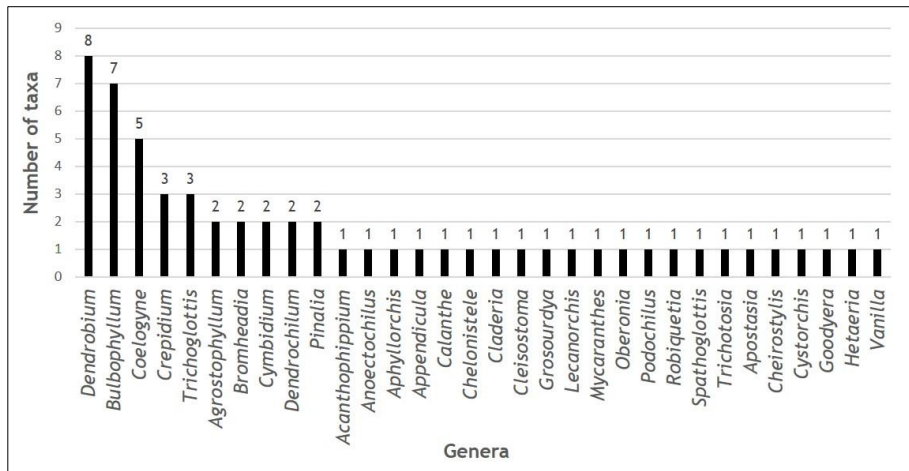


Figure 5. Number of orchid genera found in Kadamaian.

The inland lower montane forest of Nopungguk harboured the most abundant orchid species (Figure 6), as it is roofed by emergent trees, shaded and moist. Also, the trail is undisturbed and longer than the other visited sites, which provided more opportunity to encounter orchids. The soil in this area is typically that of humus and peat forming the upper layer. This is likely due to a high soil water content, reduced sun radiation, and low rates of decomposition. Epiphytic orchids were in great abundance, notably the necklace orchids, *Coelogyne* and its allied genera such as *Chelonistele*, *Dendrochilum*, and *Pholidota*. Also, in great abundance are species of *Bulbophyllum* and *Dendrobium*. However, terrestrial orchids also showed a high dominance as the shady and moist forest floor was ideal for their growth.

The riverine forest should have accumulated an abundant orchids species, particular favourites of epiphytes that prefer microclimates where it is often cooler, with swift air currents (Wood, 2008). However, the Melangkap Noriou trail was deeply shaded and dark even during the daytime where sunlight was perching above the canopy. Presumably, the thick canopy roofed the lower canopy area, limiting exposure to sunlight. For orchids, lower light levels and too low temperatures are limiting factors and here they are less abundant (Wood, 2008). Also, 100m from the trail's entrance is a secondary forest and rubber plantation. The secondary forest is occupied by the pioneers, such as *Macaranga*. Invasive species from family Poaceae and Cyperaceae were also very prominent in this area. Such forests are poor in orchid species diversity (Wood,

2013). Only a few *Dendrobiums* found a refuge in the plantations, including *D. acerosum*.

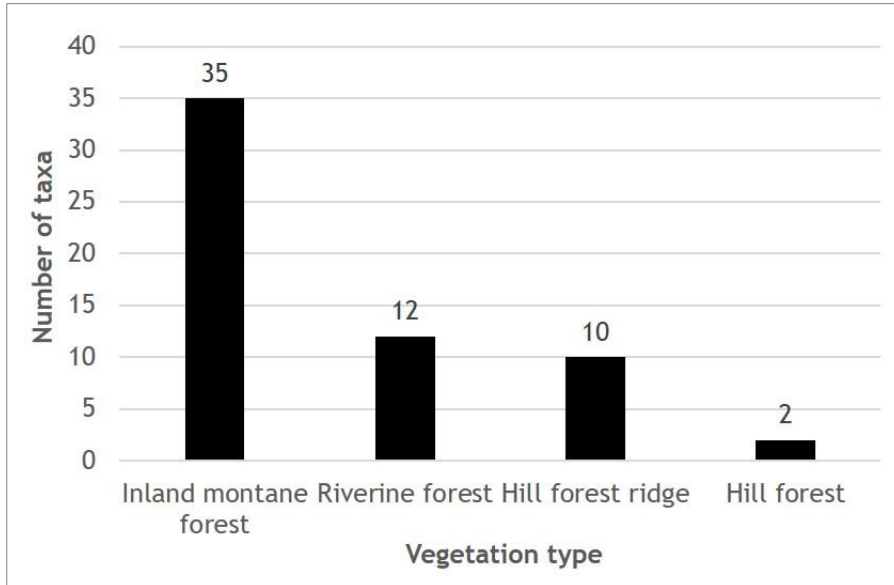


Figure 6. Number of orchid species from different vegetation types found in Kadamaian.

Four species were endemic to Borneo; *Appendicula congesta*, *Bulbophyllum disjunctum*, *Dendrobium kiauense*, and *Goodyera rostellata*, with *Crepidium multiflorum*, a hyper-endemic species, endemic to Mount Kinabalu area. Three of the endemic species, *A. congesta*, *B. disjunctum*, and *D. kiauense*, were found in the Nopungguk trail, a relatively undisturbed inland montane forest, dominated by tall trees with thick interlocking crown, allowing very minimal sunlight exposure. Meanwhile, *G. rostellata* was found in the Melangkap Noriou trail, a riverine forest connected to a secondary forest and a rubber plantation. Several species narrowly distributed to the primary forest habitat were discovered, including a jewel orchid; *Cystorchis variegata* var. *variegata* and *Anoectochilus geniculatus* (Figure 7). Notably, a rare jewel orchid, or probably a new one, was found during the expedition. We have not managed to accurately identify the specimen to its respective taxa nor the genus. In this paper, it is conferred to a *Cheirostylis* species referring to the leaf pattern (Figure 7H). None of the known jewel orchids genera in Borneo resembles our specimen. A further study could not be carried out as no other specimen was collected.

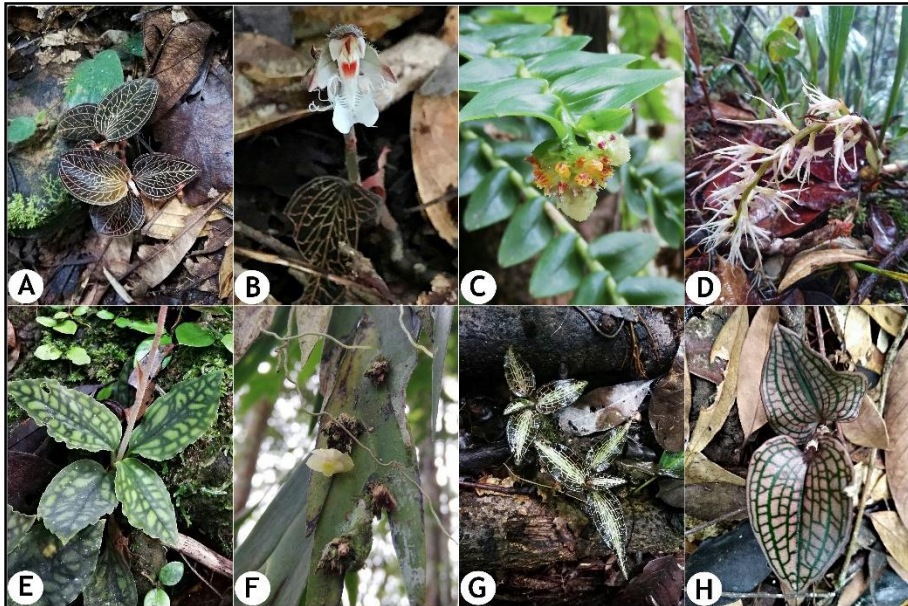


Figure 7. Rare and endemic orchid species found in Kadamaian: A) *Anoectochilus geniculatus* (plant); B) *Anoectochilus geniculatus* (flower); C) *Appendicula congesta*; D) *Bulbophyllum disjunctum*; E) *Cystorchis variegata* var. *variegata*; F) *Dendrobium kiauense*; G) *Goodyera rostellata*; H) Unidentified plant (cf. *Cheirostylis*).

Crepidium multiflorum is an erect plant with flowers small, non-resupinate, the front edge of the lip simple or more or less 3-lobed, and the apical part often emarginated or bilobulate (Figure 8). Also, the plant that we discovered is very similar to the holotype of *Clemens AMES 16941* (AMES-photo!), similar in the size of the plant, the spreading ovate to wide elliptic leaves, morphology of the flowers based on the illustrations on the herbarium sheets, except the flowers of *C. multiflorum* described in the holotype are orange whereas our plants have flowers that are greenish-yellow. The *C. multiflorum* is almost identical to *C. balabacense* and *C. moluccanum* in both vegetative and floral morphologies. However, the latter two species have not been recorded in Borneo until now. Further revision of this complex is recommended to evaluate the legitimate status. It commonly occurs in hill forest at elevation 900-1,200m above sea level (Wood et al., 1993). In the current study, the plant was found growing along with *Spathoglottis aurea* on a disturbed ground along the margin of a four-wheel off-road track situated just above our basecamp.



Figure 8. *Crepidium multiflorum*: A) Inflorescence; B) Plant.

Importantly, we discovered two mycoheterotrophs; *Aphyllorchis pallida* and *Lecanorchis multiflora* var. *multiflora*. The occurrence of these flagship species along the trails were rare with 2-3 individuals growing along the mentioned trails. The findings were listed in Table 2. The checklist includes brief information on each species growth habits, sites, and vegetation types. Some of the collected orchid species are shown in the Colour Plate (Figure 9). Among the selected sites, Melangkap Noriou trail was the most disturbed and occupied invasive species and these were seen to affect the abundance of wild orchids in the area. If the disturbance is not minimized and appropriate conservative measures, especially habitat restoration, are not taken, the effect of habitat destruction and ecological alteration will be detrimental and eventually destroy the vulnerable terrestrial orchids in the area. The Nopungguk trail was relatively undisturbed and there was no sign of destruction in the area. Presence of the jewel and terrestrial orchid species in a forest area serve as an indicator of a pristine environment. The selected sites are all within the Kinabalu Park area and put under the care of Sabah Parks, which is considerably well-protected under their jurisdiction. To quote Juiling et al. (2020), a collaboration with any ex-situ conservatories in Sabah, especially the Poring Orchid Garden, as well as local community for wild orchids ex-situ conservation is highly recommended.

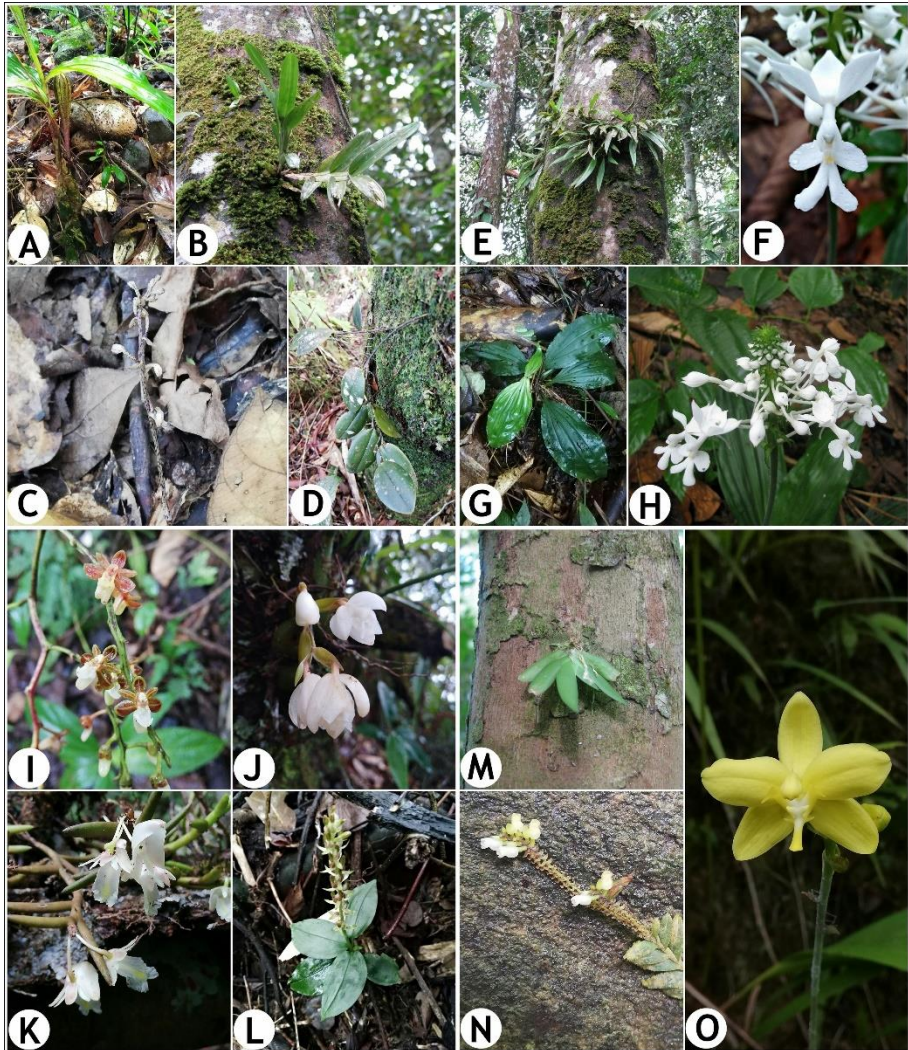


Figure 9. Wild orchids of Kadamaian and their growth habit: A) *Acanthophippium javanicum*; B) *Agrostophyllum* sp.; C) *Aphyllorchis pallida*; D) *Bulbophyllum* sp.; E) *Bulbophyllum* sp.; F) *Calanthe triplicata* (flower); G) *Calanthe triplicata* (plant); H) *Calanthe triplicata* (flowers); I) *Cleisostoma racemiferum*; J) *Coelogyne clemensii*; K) *Dendrobium acerosum*; L) *Hetaeria* sp.; M) *Oberonia* sp.; N) *Podochilus lucescens*; O) *Spathoglottis aurea*.

Table 2. Preliminary list of orchid taxa found in the selected sites in Kadamaian, Sabah.

No	Subfamilies	No	Genera	No	Taxa	Growth habits	Localities				
1	Epidendroideae	1	<i>Acanthophippium</i>	1	<i>A. javanicum</i> Blume	TR	MN				
		2	<i>Agrostophyllum</i>	2	<i>A. sp</i> (1)	EP	NP				
		3		<i>A. sp</i> (2)	EP	NP					
		3	<i>Anoectochilus</i>	4	<i>A. geniculatus</i> Ridl.	TR	NP				
		4	<i>Aphyllorchis</i>	5	<i>A. pallida</i> Blume	MH	NP				
		5	<i>Appendicula</i>	6	<i>A. congesta</i> Ridl.	EP	NP				
		6	<i>Bromheadia</i>	7	<i>B. brevifolia</i> Ridl.	7	<i>B. brevifolia</i> Ridl.	EP	NP		
				8	<i>B. sp.</i>	8	<i>B. sp.</i>	TR	NP		
				7	<i>Bulbophyllum</i>	9	<i>B. disjunctum</i> Ames & C.Schweinf. in O.Ames	9	<i>B. disjunctum</i> Ames & C.Schweinf. in O.Ames	EP	NP
						10	<i>B. membranaceum</i> Teijsm. & Binn.	10	<i>B. membranaceum</i> Teijsm. & Binn.	EP	SM
						11	<i>B. sp</i> (1)	11	<i>B. sp</i> (1)	EP	NP
						12	<i>B. sp</i> (2)	12	<i>B. sp</i> (2)	EP	NP
						13	<i>B. sp</i> (3)	13	<i>B. sp</i> (3)	EP	NP
						14	<i>B. sp</i> (4)	14	<i>B. sp</i> (4)	EP	NP
						15	<i>B. sp</i> (5)	15	<i>B. sp</i> (5)	EP	SM
						16	<i>C. triplicata</i> (Willemet) Ames	16	<i>C. triplicata</i> (Willemet) Ames	TR	NP & MN
		9	<i>Chelonistele</i>	17	<i>C. cf. sulphurea</i>	17	<i>C. cf. sulphurea</i>	EP	NP		
		10	<i>Claderia</i>	18	<i>C. viridiflora</i> Hook.f.	18	<i>C. viridiflora</i> Hook.f.	EP	NP		
		11	<i>Cleisostoma</i>	19	<i>C. racemiferum</i> (Lindl.) Garay	19	<i>C. racemiferum</i> (Lindl.) Garay	EP	MN		
		12	<i>Coelogyne</i>	20	<i>C. clemensii</i> Ames & O.Ames	20	<i>C. clemensii</i> Ames & O.Ames	EP	NP		
				21	<i>C. cuprea</i> H.Wendl. & Kraenzl.	21	<i>C. cuprea</i> H.Wendl. & Kraenzl.	EP	NP		
				22	<i>C. sp</i> (1)	22	<i>C. sp</i> (1)	EP	NP		
				23	<i>C. sp</i> (2)	23	<i>C. sp</i> (2)	EP	NP		
				24	<i>C. sp</i> (3)	24	<i>C. sp</i> (3)	EP	SM		
				13	<i>Crepidium</i>	25	<i>C. multiflorum</i> (Ames & C.Schweinf.) Szlach.	25	<i>C. multiflorum</i> (Ames & C.Schweinf.) Szlach.	TR	B
						26	<i>C. sp</i> (1)	26	<i>C. sp</i> (1)	TR	MN
						27	<i>C. sp</i> (2)	27	<i>C. sp</i> (2)	TR	MN
						28	<i>C. sp</i> (1)	28	<i>C. sp</i> (1)	EP	NP
				14	<i>Cymbidium</i>	29	<i>C. sp</i> (2)	29	<i>C. sp</i> (2)	EP	MN
		30	<i>D. acerosum</i> Lindl.			30	<i>D. acerosum</i> Lindl.	EP	MN		
		15	<i>Dendrobium</i>	31	<i>D. crumenatum</i> Sw.	31	<i>D. crumenatum</i> Sw.	EP	NP		
				32	<i>D. kiauense</i> Ames & O.Ames	32	<i>D. kiauense</i> Ames & O.Ames	EP	NP		
				33	<i>D. sp</i> (1)	33	<i>D. sp</i> (1)	EP	NP		
				34	<i>D. sp</i> (2)	34	<i>D. sp</i> (2)	EP	NP		
				35	<i>D. sp</i> (3)	35	<i>D. sp</i> (3)	EP	SM		
				36	<i>D. sp</i> (4)	36	<i>D. sp</i> (4)	EP	SM		
				37	<i>D. villosulum</i> Wall. ex Lindl.	37	<i>D. villosulum</i> Wall. ex Lindl.	EP	NP		
				38	<i>D. sp</i> (1)	38	<i>D. sp</i> (1)	EP	NP		
		16	<i>Dendrochilum</i>	39	<i>D. sp</i> (2)	39	<i>D. sp</i> (2)	EP	NP		
				40	<i>G. sp.</i>	40	<i>G. sp.</i>	EP	SM		

	18	<i>Lecanorchis</i>	41	<i>L. multiflora</i> J.J.Sm. var. <i>multiflora</i>	MH	NP	
	19	<i>Mycaranthes</i>	42	<i>M. sp.</i>	EP	NP	
	20	<i>Oberonia</i>	43	<i>O. sp.</i>	EP	MN	
	21	<i>Pinalia</i>	44	<i>P. sp</i> (1)	EP	NP	
			45	<i>P. sp</i> (2)	EP	MN	
	22	<i>Podochilus</i>	46	<i>P. lucescens</i> Blume	EP	SM	
	23	<i>Robiquetia</i>	47	<i>R. sp.</i>	EP	SM	
	24	<i>Spathoglottis</i>	48	<i>S. aurea</i> Lindl.	TR	B	
	25	<i>Trichoglottis</i>	49	<i>T. sp</i> (1)	EP	NP	
			50	<i>T. sp</i> (2)	EP	NP	
			51	<i>T. sp</i> (3)	EP	SM	
	26	<i>Trichotosia</i>	52	<i>T. sp.</i>	EP	NP	
2	Apostasioideae	27	<i>Apostasia</i>	53	<i>A. nuda</i> R.Br. in N.Wallich	TR	NP
3	Orchidoideae	28	<i>Cheirostylis</i>	54	<i>C. sp.</i>	TR	NP
		29	<i>Cystorchis</i>	55	<i>C. variegata</i> Blume var. <i>variegata</i>	TR	SM
		30	<i>Goodyera</i>	56	<i>G. rostellata</i> Ames & C.Schweinf. in O.Ames	TR	MN
		31	<i>Hetaeria</i>	57	<i>H. sp.</i>	TR	MN
4	Vanilloideae	32	<i>Vanilla</i>	58	<i>V. sp.</i>	EP	MN

Notes: EP = Epiphytic, TR = Terrestrial, MH = Mycoheterotrophic, NP = Nopunguk, MN Melangkap Noriou, SM = Ulu Sungai Melawa, B = Hill near basecamp area.

Conclusions and Recommendations

Our collection of 58 orchid species belonging to four subfamilies is considerably high despite the brief visit and limited time spent in the selected sites. Here, we emphasize the importance of undisturbed vegetation type on the species abundance, where the highest abundance was found in the inland montane forests. No species is listed as a new record as most of the specimens have not been completely identified to the respective taxa due to lack of floral structures. One limitation of our current study is insufficient samples. Nevertheless, there could be more to be discovered in the highland area due to the undisturbed environment. Protection of the undisturbed forest area, especially the Mount Nopunguk and Ulu Sungai Melawa areas, is imperative to ensure the survival and richness of these precious wild orchids are maintained. Mount Nopunguk has great potential as a hiking spot where tourists would enjoy the magnificent view of Mount Kinabalu up-close. To reverse the threats, an integrated diversity and population study, and ecology and conservation assessments in the Kadamaian area must first be conducted.

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