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The Diversity of *Hoya* (Apocynaceae: Asclepiadoideae) in Some Parts of Kedah and Perak, Peninsular Malaysia

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ABSTRACT

This study provided data on the diversity of *Hoya* species reported to occur in some parts of the northern region of Peninsular Malaysia. Seven locations were chosen between two states, Kedah (Lata Celak, Sedim, and Bukit Hijau) and Perak (Mahang, Belukar Semang, Sungai Rui, and Pondok Tanjung). This extensive fieldwork was carried out from 2018 until the end of 2019 to provide a baseline checklist for this genus in this northern region. All living specimens found were recorded, and some species were cultivated for further identification and *ex-situ* conservation purposes. A total of 27 species and one variety were recorded, out of which 15 species were newly reported for the northern region of Peninsular Malaysia. The newly described species, *Hoya peninsularis* Rodda & Zakaria, was also reported in this study. One unknown species was found and labelled as *Hoya* sp. cf. *scortechinii*. Further identification process together with molecular analysis of this plant is still ongoing. The most diverse forests are Sungai Rui and Lata Celak, having the Shannon index of 2.741 and 2.622, respectively. Both forests possess the richest in *Hoya* species, but with low dominance index. The Sorenson similarity index is 6.74%, indicating a very low similarity of *Hoya* species between the studied sites. Due to the high diversity recorded, the number of *Hoya* species in the country is expected to increase if the genus is explored continuously. However, most of the study areas were exposed to extreme logging activities and had a high degree of human disturbances, indicating the need for intensive conservation efforts in this genus.

Keywords: Checklist, conservation, diversity, *Hoya*, northern region, Peninsular Malaysia

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INTRODUCTION

The epiphytic genus *Hoya* R. Br. is one of the most species-rich genera of the tribe Marsdenieae of Asclepiadoideae (Apocynaceae). This genus includes 350–450 currently accepted species found throughout the tropics and sub-tropics regions of Asia and Australia (Lamb & Rodda, 2016). Some of the species of this genus are still being newly discovered and described, particularly from the Malaysian part of Borneo Island (Rodda, 2015). In Peninsular Malaysia, *Hoya* has been revised three times (Rodda & Simonsson, 2013). This includes 23 species by King and Gamble (1908), 25 species by Ridley (1923), and 25 species by Rintz (1978). Other revisions that were published later reported 27 species of *Hoya* (Kiew, 1989; Rodda & Simonsson, 2012). However, a recent study proved that numerous species could be discovered by searching through the available herbarium specimens (Salim & Nikong, 2020).

Hoya species are lactiferous epiphytic lianas mostly characterised as having milky saps. They are commonly known as waxy plants due to the waxy appearance of their leaves and flowers. Hoyas are evergreen plants whose leaves are positioned oppositely on each node, and the leaf shapes vary from orbicular to linear (Kleijn & van Donkelaar, 2001; Wanntorp, 2009). They have unusual floral morphology, i.e. extra-axillary umbelliform inflorescence and star-shaped corona. This makes *Hoya* plants popular ornamentals (Wanntorp & Kunze, 2009). Generally, hoyas can be found in places with high humidity and good sunlight exposures (Hansen et al., 2007; Rahayu et al., 2018; Rintz, 1980). These climbers can be seen along the rivers and streams, and usually occupy the lower canopy of forests (Rahayu et al., 2010).

Usually, to maximise exposure to sunlight, *Hoya* species use the big trees as host plants. The host plants have rough and notched bark textures that accumulate humus and litter, thereby facilitating the growth of *Hoya* species (Sulaeman et al., 2019). Many of the epiphytes are associated with arboreal ants (Davidson & Epstein, 1989). Therefore, *Hoya* plants are known as myrmecophytes or called as ant-plants (Kleijn & van Donkelaar, 2001; Orivel & Leroy, 2011). They usually provide shelter and food for these types of ants. In return, these ants build carton nests that contain organic materials for the plants as nutrients (Corbara et al., 1999). The presence of these ants can also promote seed dispersal (Wagner, 1997).

Hoyas are not only recognised for the beauty of their flowers, but are also plants with several uses such as pollutant-absorbers (Yang et al., 2009). They are also known as sources of certain medicinal and pharmaceutical compounds (Barukial & Sarmah, 2011; Gautam et al., 2013; Mollik et al., 2010). Based on Wanntorp et al. (2006), new species of *Hoya* are added each year. However, the most common threat faced by hoyas is habitat degradation. Clearing of the host plants has threatened *Hoya* populations and may lead to the extinction of species. The hoyas are rarely found blooming in the

wild. Therefore, continuous visits to similar sites are often required to ensure recording and collecting plants in bloom.

This study aimed to develop an inventory of *Hoya* species found in certain parts of the northern region of Peninsular Malaysia. Previous studies (Kiew, 1989; Rintz, 1978; Rodda & Simonsson, 2012) were mostly focused on central and eastern parts of the peninsular. Thus, it is essential to have an adequate understanding of the presence, conservation status, and ecological role of *Hoya* species in the forest by conducting the quantitative monitoring of its diversity.

MATERIALS AND METHODS

The sampling of *Hoya* species was conducted from January 2018 until December 2019. The sampling was focused on some parts of the northern region of Peninsular Malaysia (Kedah and Perak). Seven study sites were chosen between the two states, involving rivers or streams that were easily accessible and containing good habitats for hoyas (Table 1). The fieldwork was focused on areas near streams and lower canopy, as hoyas prefer to occupy areas with high humidity and good exposure to sunlight. Each of the sampling sites was accessed multiple times to maximise the finding. Modified line transect method was used for the sampling. A line transect of 1,000 meters was set at each site along the river bank as the primary reference route. The specimens of hoyas were collected and identified to the lowest taxa using the taxonomic keys (Lamb & Rodda, 2016; Rintz, 1978). The identification process was made easier by one of the authors, who was a taxonomist and *Hoya* specialist.

Digital images of the whole plants or parts of it that were available at the collection time were also obtained to facilitate species identification. The plants without flowers and difficult to identify were grown *ex-situ* at Universiti Sains Malaysia (USM) plant nursery. Voucher specimens were deposited at the Herbarium Unit, USM.

The PAST 4.0 software (Hammer et al., 2001) was used to quantify the diversity indices, including Shannon index, Simpson index, and species evenness. A non-parametric rarefaction and extrapolation analysis with 500 bootstrap replicates was used to estimate the species richness of *Hoya* at the sampled sites (Chao et al., 2016). This

Table 1
List of study sites

Study sites	Type	Gps coordinate	Altitude (m)
Lata Celak, Kedah	Lowland dipterocarp	5°34'N 100°51'E	200-300
Sedim, Kedah	Lowland dipterocarp	5°24'N 100°46'E	200-300
Bukit Hijau, Kedah	Lowland dipterocarp	5°30'N 100°46'E	200-300
Mahang, Perak	Hill dipterocarp	5°19'N 100°45'E	450-800
Belukar Semang, Perak	Lowland dipterocarp	5°34'N 100°59'E	200-300
Sungai Rui, Perak	Lowland dipterocarp	5°26'N 101°06'E	200-300
Pondok Tanjung, Perak	Peat swamp forest	4°59'N 100°43'E	100-200

analysis was based on avoiding the bias that involved species with only single individuals at any of the sites. The confidence intervals of the species curves were used to determine the significant differences in the species richness between the sites. This analysis was done using iNEXT online software (Chao et al., 2016). The Sorenson similarity index was determined to assess the similarities in the species between the sampled sites, using the equation below:

$$Sc = (2W/a) \times 100\% \text{ (Sorenson, 1948)}$$

where *Sc* is the similarity coefficient, *W* represents the number of species common to all sites, and *a* means the sum of all the number of species observed at each of the study sites.

RESULTS AND DISCUSSION

A total of 784 *Hoya* plants were recorded from the seven study sites, which consist of 27 species and one variety (Table 2). Earlier researchers recorded 27 species of *Hoya* in Peninsular Malaysia (Kiew, 1989; Rintz, 1978; Rodda & Simonsson, 2012), and this study recorded 89% of them in the sampling areas. From this study, 15 taxa were newly reported for the northern region of Peninsular Malaysia. They include *Hoya beccarii*, *Hoya coronaria*, *Hoya diversifolia*, *Hoya elliptica*, *Hoya erythrina*, *Hoya erysthrostemma*, *Hoya flagellata*, *Hoya forbesii*, *Hoya ignorata*, *Hoya javanica*, *Hoya lasiantha*, *Hoya mitrata*, *Hoya parviflora*, *Hoya verticillata*, and *Hoya verticillata* var. *hendersonii*. The newly described species, *Hoya peninsularis* Rodda & Zakaria (Rodda & Zakaria, 2020) was also found in this study (Figure 1). This species has been long confused with *Hoya finlaysonii* due to their similar leaf morphology. One unknown species was found in this study and was labelled as *Hoya* sp. cf. *scortechinii* (Figure 2). It has similar inflorescences with *Hoya scortechinii* but differs in colour and the leaves. Further identification process with the aid of molecular analysis is still ongoing to clarify the status of this particular species. *H. ignorata* (Figure 3), which was recently rediscovered in Terengganu (Salim & Nikong, 2020), as this species was previously reported by Corner in 1934 at Kemaman, Terengganu (Trân et al., 2011) was also found in three different sites. The most common and abundantly distributed species from all the study sites is *Hoya revoluta* (101; Figure 4), followed by *H. finlaysonii* (81; Figure 5). Both species were found to adapt to a vast range of environmental parameters and are distributed at different levels of altitude.

A few uncommon species with fewer individuals such as *Hoya curtisii* (1), *H. flagellata* (2), *Hoya mappigera* (2), *H. verticillata* var. *hendersonii* (2), and *Hoya imperialis* (3) were observed. This result suggests that a broader collection effort should be conducted in the future to update the record of *Hoya* by focusing on the selected forests around Kedah and Perlis. It is observed that a few species, namely *H. ignorata*, *H. imperialis*, and *H. mappigera*, which are also found in some

Table 2
List of Hoya *species found at each of the study sites*

S/N	Name of species	Study sites						
		Lata Celak	Sedim	Bukit Hijau	Mahang	Belukar Semang	Sungai Rui	Pondok Tanjung
1	*Hoya beccarii* Rodda & Simonsson (voucher: RZ/19/021)	√	x	x	x	√	√	x
2	*Hoya caudata* Hook. f. (voucher: RZ/19/036)	√	√	√	√	√	√	√
3	*Hoya coriacea* Blume (voucher: RZ/18/016)	√	x	x	√	x	√	√
4	*Hoya coronaria* Blume (voucher: RZ/19/033)	√	x	x	x	√	√	√
5	*Hoya curtisii* King & Gamble (voucher: RZ/19/032)	√	x	x	x	x	x	x
6	*Hoya diversifolia* Blume (voucher: RZ/18/008)	√	x	x	x	x	x	√
7	*Hoya elliptica* Hook. f. (voucher: RZ/18/005)	√	√	√	x	√	√	√
8	*Hoya erythrina* Rintz (voucher: RZ/19/031)	√	x	x	x	√	√	√
9	*Hoya erysthrostemma* Kerr (voucher: RZ/18/011)	x	x	x	x	x	√	x
10	*Hoya finlaysonii* Wight (voucher: RZ/18/019)	√	x	√	√	√	√	√
11	*Hoya flagellata* Kerr (voucher: RZ/19/035)	√	√	x	x	x	x	x
12	*Hoya forbesii* King & Gamble (voucher: RZ/18/012)	√	√	√	√	√	√	√
13	*Hoya ignorata* T. B. Tran, Rodda, Simonsson & Jongku Lee (voucher: RZ/19/036)	√	x	x	√	x	√	x
14	*Hoya imperialis* Lindl. (voucher: RZ/19/026)	x	x	x	x	x	√	x
15	*Hoya javanica* Boerl. (voucher: RZ/18/006)	√	x	x	√	x	√	x
16	*Hoya lacunosa* Blume (voucher: RZ/18/007)	√	x	x	x	√	√	√
17	*Hoya lasiantha* Korth. ex Miq. (voucher: RZ/18/016)	√	√	√	x	x	√	√
18	*Hoya latifolia* G. Don (voucher: RZ/18/27)	x	x	x	x	x	√	x

Table 2 (*continue*)

S/N	Name of species	Study sites						
		Lata Celak	Sedim	Bukit Hijau	Mahang	Belukar Semang	Sungai Rui	Pondok Tanjung
19	*Hoya mappigera* Rodda & Simonsson (voucher: RZ/19/024)	x	x	x	x	x	√	x
20	*Hoya mitrata* Kerr (voucher: RZ/19/020)	x	x	x	√	x	√	x
21	*Hoya obtusifolia* Wight (voucher: RZ/18/013)	√	x	x	x	x	√	x
22	*Hoya parviflora* Wight (voucher: RZ/18/009)	√	x	√	x	√	√	x
23	*Hoya revoluta* Wight ex Hook. f. (voucher: RZ/18/006)	√	√	√	√	√	√	√
24	*Hoya scortechinii* King & Gamble (voucher: RZ/18/003)	x	√	x	√	x	x	x
25	*Hoya verticillata* (Vahl) G. Don (voucher: RZ/18/017)	x	√	√	√	x	√	x
26	*Hoya verticillata* (Vahl) G. Don var. *hendersonii* (Kiew) Veldkamp (voucher: RZ/18/015)	√	x	x	x	x	x	x
27	*Hoya peninsularis* Rodda & Zakaria (voucher: RZ/19/29)	x	x	x	x	x	x	√
28	*Hoya* sp. cf. *scortechinii* (voucher: RZ/19/038)	x	x	x	x	x	x	√

Note. √ means present, x means absent

Figure 1. The inflorescence of *Hoya* sp. cf. *scortechinii* at the study sites

Figure 2. The inflorescence of *Hoya peninsularis* at the study sites

Figure 3. The inflorescence of *Hoya ignorata* at the study sites

Figure 4. The inflorescence of *Hoya revoluta* at the study sites

Figure 5. The inflorescence of *Hoya finlaysonii* at the study sites

parts of Thailand, are well distributed in the northern part of the peninsular, as this region is closer to Thailand (Rodda & Simonsson, 2012; Trân et al., 2011; Wai et al., 2008).

The major factors that limit the distribution of epiphytes are light, water, and mineral nutrition (Benzing, 2008; Luttge, 2008). The majority of hoyas were found hanging on phorophytes near water stream or river, except a few of them, such as *H. erythrina* and *H. verticillata*, which grow on damp boulders and rocks. Although *Hoya* species mostly occur in areas with high humidity, it could be also be found in very dry habitats for extended periods (Rahayu, 2012). Habitat heterogeneity probably affects epiphyte distribution, whether it is seedling germination or recruitment success (Winkler et al., 2005). Through observation, no specific host plant selection for hoyas was found in this study. This finding is supported by previous studies stating that there is no particular association between hoyas and the host plants (Damayanti et al., 2017; Zakaria et al., 2019). Hoyas are observed to choose their host plants mainly for sunlight exposure.

It was observed that Sungai Rui had the highest number of *Hoya* species (21), the highest number of individuals (281), and the highest Shannon index ($H' = 2.741$), followed by Lata Celak with 19 species of *Hoya* and Shannon index of 2.622 (Table 3). The higher *Hoya* diversity could be due to several factors that may be investigated in future studies. The lowest number of species (8) was recorded in Sedim and Bukit Hijau. These two studied sites are known as recreational forests with some degree of

Table 3
The Hoya *diversity indices of the study sites*

Parameters	Lata Celak	Sedim	Bukit Hijau	Mahang	Belukar Semang	Sungai Rui	Pondok Tanjung
No. of taxa (*S*)	19	8	8	10	10	21	13
Individuals	75	26	52	105	115	281	130
Dominance (*D*)	0.09227	0.2012	0.2345	0.2472	0.1341	0.07575	0.1336
Shannon (*H'*)	2.622	1.778	1.669	1.688	2.097	2.741	2.243
Evenness *e*H/S*	0.7241	0.7399	0.6633	0.5409	0.8146	0.7385	0.7245

human disturbances marked with logging and other activities (Rahmad & Akomolafe, 2019). Hence, this might be responsible for the lower number of species and the lowest number of individuals of the species. Bukit Hijau and Mahang forests were observed to have the lowest diversity of Hoya species with Shannon index of 1.669 and 1.688, respectively. The same forests possessed the highest dominance index of 0.2345 and 0.2472, respectively. This is very understandable because some species are expected to dominate the site with a lower diversity of plant species; hence, a higher dominance index is expected (Sasaki & Lauenroth, 2011). The highly diverse forests could be regarded as more functional and stable than the less diverse ones (Allan et al., 2011).

It is worthy to note that the Bukit Hijau and Mahang forests were the forests with the lowest species evenness index 0.6633 and 0.5409, respectively. This could only suggest a direct relationship between Shannon index and evenness index because the sites with the lowest Shannon index also had the lowest evenness index; hence, rendered less productive (Allan et al., 2011). The rarefaction and extrapolation estimation of the species richness revealed

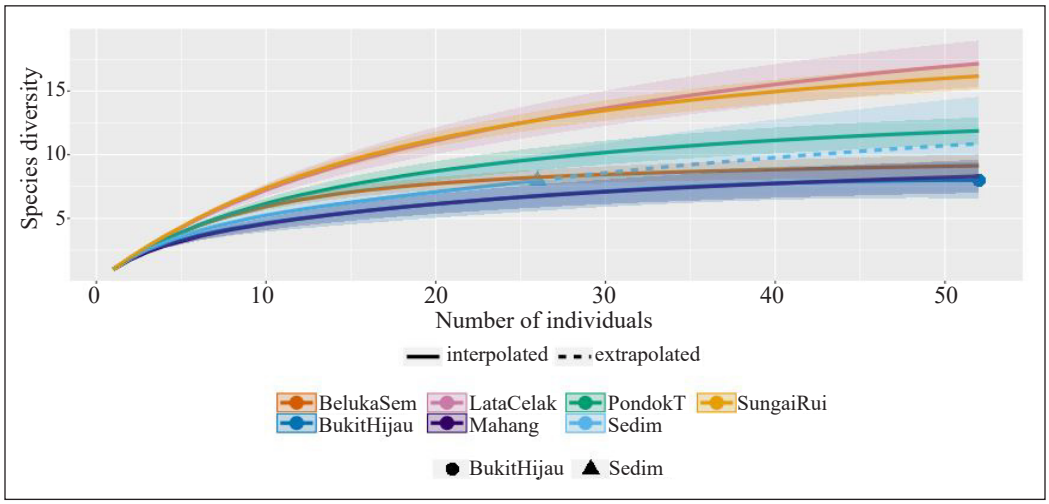

Figure 6. Sample-based rarefaction and extrapolation curve for the species richness of *Hoya* at the study sites

that Sungai Rui and Lata Celak forests had the highest species richness. However, their differences are not significant based on the overlapped confidence intervals (Figure 6). However, their species richness is significantly different from the other forests. The low number of Sorenson similarity index (6.74%) indicated the low similarities of Hoya species between the sampled sites.

CONCLUSION

This current checklist could be considered as a new and updated *Hoya* collection for northern Peninsular Malaysia. This study provided a view of the richness and diverse nature of the studied forests in terms of *Hoya* species, mainly in the northern area. More undiscovered or new species could be identified if a more comprehensive study was undertaken. The quantitative monitoring of *Hoya* diversity can provide fundamental understanding in detecting the changes in the species population. The results of this study can be useful in providing practical strategies for the conservation of *Hoya* species. Moreover, it is also important that the strategies are strictly implemented to protect forests that are essential for the survival and spread of this species.

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