



Morphology of *Hoya megalaster* Warb. Ex K. Schumann & Lauterb and *Hoya pachyphylla* Warb. Ex K. Schumann & Lauterb (Apocynaceae) from New Guinea, Indonesia

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

New Guinea is one the mega-diverse regions of the world and a host to 6% of the world's biodiversity. Recently, land clearing and forest fragmentation associated with rapid economic growth have become growing threats to biodiversity in New Guinea. One of the several taxa of plants that is affected due to the rapid destruction of its known host plants is the genus *Hoya*. We describe the vegetative and reproductive morphology of two species of *Hoya* that are found in the primary forest of Papua in Ubiyau Village, a remote area in West Papua, Indonesia: *Hoya megalaster* and *H. pachyphylla*. Both species are perennial climbing epiphytes with opposite

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phyllotaxy, and short-lived cymes that are positively geotropic. The two species differ in leaf morphology. *Hoya megalaster* has a thin lamina, while the leaves of *H. pachyphylla* are succulent. We provide a list of characters that can potentially be used for future morphometric and phylogenetic studies on these two species.

Keywords: Floral diversity; Hoyas; Keerom; Papua; wax flower.

1. INTRODUCTION

Hoya R. Br (henceforth referred to as Hoya or Hoyas) is the largest genus of the family Apocynaceae [1]. Hoyas are increasingly popular as ornamental plants for indoor or outdoor uses due to their aromatic and attractive flowers [2]. Depending on the cultivar, rarity, and uniqueness of the inflorescences, they can have relatively high values in the floriculture market [3].

The centres of diversity of *Hoya* are tropical and subtropical South Asia, Southeast Asia and Papuasia, with approximately 450 species found [4]. Papuasia is one of the richest botanical regions defined in the World Geographical Scheme for Recording Plant Distribution (WGSRPD). It lies in the Southwest Pacific Ocean in the Melanesia Eco-Region of Oceania and tropical Asia. Papuasia comprises Aru Islands, West Papua (Papua Province and West Papua Province) in Eastern Indonesia, Papua New Guinea and Solomon Islands (excluding

Santa Cruz Islands). The majority of described species of *Hoya* in New Guinea were originally from Papua New Guinea, while the origin of *Hoya* in Indonesia New Guinea is poorly documented.

Papua is one of the most biologically diverse but least explored provinces in Indonesia [5]. New Guinea Island falls under two countries: Indonesia in the western half (Papua Province and West Papua Province) and Papua in the eastern half (Fig. 1). The species and habitats found in Papua are under huge threat due to deforestation, environmental damage, illegal hunting and trade [6-8]. It was reported that in 2019, 11% of the 1.3 million ha forest in Papua had been cleared [9]. Very limited information on biodiversity in Papua New Guinea is available, mainly because of the remote distance from the capital city and limited access to the area. A priority list of global centres for preservation of biological diversity in this area is required.

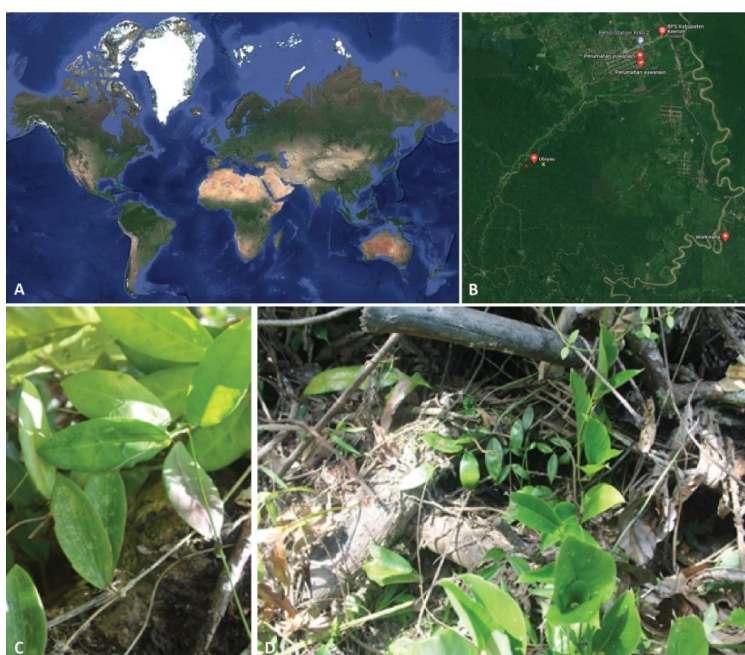


Fig. 1. (A) Global distribution of *H. megalaster* and *H. pachyphylla*. (B) Survey site where *H. megalaster* and *H. pachyphylla* were found at Ubiyau forest, Arso D istrict, Keerom, West Papua. Habit and habitat of (C) *H. megalaster* and (D) *H. pachyphylla*. X indicates the location of *H. megalaster* whereas X of *H. pachyphylla*

New Guinea Island has 74 species of *Hoya* and less than half of them have been found in Papua and West Papua provinces, i.e. Indonesia New Guinea [10]. There are species from Papua New Guinea and Solomon Islands that have been described [11,10].

One of the key reproductive characters to evaluate when describing Hoyas is the presence of five staminal coronal lobes attached to the staminal column [12]. In the absence of reproductive organs, the use of leaf characters can be used to describe Hoyas, such as the study conducted by Jumawan & Buot [13] on the Hoya diversity in the Philippines.

Hoya can grow in a great variety of habitats, including rainforest, foreshore and associated mangrove communities, to an extreme habitat such as dry areas with sandstone escarpment [12]. Generally, species of *Hoya* grow as climbers and are usually found hanging on the tree branches and crown of trees. Their flowers are glossy and arranged in inflorescences. The leaf anatomy of *Hoya* species was found to be highly variable [14]. Many species of *Hoya* have thick and succulent leaves, but some species have thin lamina [15,16].

About 200 species of *Hoya* have been described [17-22], but many *Hoya* species have not been identified or lack locality details. It is important to describe and identify species of *Hoya*, particularly of those that are threatened and endangered in their original habitat, including in the remote and logged areas in Papua. The key character for identification is the flower structure and morphology. A preliminary survey conducted in Papua found *H. megalaster* and *H. pachyphylla* at logging areas in the low land rainforests in Arso, Keerom [23]. Our study was conducted to examine the morphological features of the different organs of *H. megalaster* and *H. pachyphylla*, which have been cultivated at the Keerom *Hoya* nursery for 3 years after collection.

2. MATERIALS AND METHODS

Samples of 40-50 cm cuttings of *Hoya* containing at least three nodes were salvaged for cultivation and conservation purposes. The cuttings were first grown in water containing a few slice of shallot for about 3 weeks; the use of shallot to induce rooting is a local practice to propagate cuttings. The rooted cuttings were transplanted into 5-L pots with top soil, moss and compost (1:1:1 by volume) and maintained at the *Hoya*

Nursery of the Papua Nature Education Foundation at Keerom, West Papua. *Hoya* identification was done by using taxonomic keys [24] and confirmed by Papua New Guinea *Hoya* expert Nathalie Simonsson Juhonewe.

Three specimens of each vegetative and reproductive organ were used for gross morphological examinations under a stereo microscope or through a hand lens. Terminology used to describe the two species of Hoyas was based on Juhonewe & Rodda [4].

3. RESULTS

3.1 Habitat Description

Approximately 88% of about 942,000 ha of the Keerom Regency were still covered by forest (Fig. 1A, 1B). The area consists of Protection Forests, Production Forests, Limited Production Forests, and Nature Reserve Area [25]. Keerom Regency consists of 11 districts, of which one is Arso, consisting of 17 villages, with an area of 1381 km², with a population of 20,214 [26]. One of the villages included in the Arso District is Ubiyau Village that has an area of 25 km². Most of the area of Ubiyau village is still primary forest and secondary forest which are located along the Ubiyau river, a long river that divides the village. Ubiyau Village is composed of around 425 people, most of whom are traditional farmers that grow crops, and raise chickens, goats and cows. The temperature in Keerom ranges from 22 to 33°C with relative humidity > 80%. The average yearly rainfall is 2200 mm, consisting of 8 to 18 rainy days per month.

Trees that dominate the Keerom primary forests are Borneo teak or Moluccan ironwood *Intsia bijuga* (Fabaceae), matoa *Pometia pinnata* (Sapindaceae), and New Guinea rosewood (*Pterocarpus indicus*, Fabaceae). Plant species that were found to grow on the trees are orchids, climbing species including rattan, *Hoya*, *Aristolochia*, *Raphidophora*, *Mucuna Benetti*, and *Epipremnum*. Species that were found growing on the forest floor are various species of *Alocasia*, *Colocasia*, *Homalomena*, *Cyrtosperma*, *Amorphophallus*, and *Schismatoglottis*.

3.2 Morphological Comparison of *H. megalaster* and *H. pachyphylla*

Hoya megalaster and *H. pachyphylla* were found climbing on what looked like the remaining trunk

of a cut ironwood tree in the forest of Ubiyau Village (Figs. 1C and 1D). *Hoya pachyphylla* has a synonym *Hoya chunii*, *Hoya chuniana*. *Hoya megalaster* was found at low population (<5 plants, whereas *H. pachyphylla* had a medium population (10 plants) in the entire survey location of 2 ha. The tree where the Hoyas climbed had been cut down and was half rotten when the Hoyas were collected. The forest in this

area has been illegally logged and the people in the area have been cutting down the large-diameter old trees and sell them as timber. Another Hoya species which appeared to be *H. lauterbachii*, was also found at low population (<5 plants) in this area, and has been collected and cultivated in the nursery. The authors are currently working with the closest herbarium in Papua on vouchering these specimens.



Fig. 2. Hoya megalaster collected from Ubiyau forest, West Papua (A) The inflorescence (B) The release of nectar from the flowers in the morning (C) Leaf pairs and inflorescence (D) young leaf (E) mature leaf

3.3 Culture Information

H. megalaster grows well in indirect light, and thrives on heat and humidity. In the nursery they were grown on well-drained media mix of soil and compost (1:1; v/v) and seem to be sensitive to over-watering. During the 3 years of culture, the collected plants have grown and have flowered three times, i.e. in October 2021, March 2022, and October 2022. Inflorescence emerged from the stem having \pm 4 mm diameter. The size of inflorescence has grown as the plants matured; the first inflorescence in the first year of culture (2021) had 6-10 flowers per inflorescence, whereas in the second year (2022) had up to 17 flowers per inflorescence.

Hoya pachyphylla grows well in indirect light, and thrives on high temperatures up to 35 °C) and high humidity that is >90%. During the three years of culture, the rescued cuttings have grown into mature plants and developed inflorescences several times. Similar to *H. megalaster*, the inflorescences of *H. pachyphylla* emerged from the stem of >4 mm thickness. *Hoya* forms flowers on the same peduncle; the number of rings on the peduncle indicated the location and the number of the previous inflorescences (Fig. 3A). Stem cuttings rescued from different plants in the forest can have different shades of flower color (Fig. 3B). The color differences may be related to the preferences of the key pollinators [27].

4. DISCUSSION

The two *Hoya* species have similarities in that both species are perennial climbing epiphytes that produce milky sap in all parts, have opposite

phyllotaxy where the leaves are borne in pairs facing each other and having an umbel inflorescence. Stems and leaves of both species are smooth with no hairs (Table 1).

The individual flower of the two species is radial in symmetry wherein the flower parts are arranged on two or more planes. Both species have five fused petals, five fused corona and five fused sepals (Figs. 2A, 3A, 3B). Inflorescence comprises of a short-lived cyme that are positively geotropic.

Notable morphological differences between the two *Hoya* species have been observed. In terms of leaf morphology, *H. megalaster* has thin lamina, green, glabrous, lanceolate shaped leaves with three midvein, rounded base and acuminate apex. Young leaf of *H. megalaster* is light brown with smooth surface (Fig. 2). A mature leaf has 15 cm long and 4 cm in width (Fig. 2E). On the other hand, *H. pachyphylla* has succulent lamina, ovate in shape with distinct vein, obtuse base and cuspidate apex. Young leaf of *H. pachyphylla* has dark brown color with fine hairs on the adaxial (Fig. 3C). The mature leaves of *H. pachyphylla* measures 9 cm to 12 cm long and 3 cm to 6 cm wide (Fig. 3D).

We noticed the emission of sweet-smelling perfume from the flowers of *H. megalaster* (Fig. 2B), but not from those of *H. pachyphylla*. According to Forster [28], some *Hoya* species emit perfume from the flowers, the intensity of which increases at dusk and persist throughout the evening. The presence of nectar indicates that this particular species may be visited by pollinators in the natural habitat [12].



Fig. 3. Inflorescence and leaves of *Hoya pachyphylla* from Ubiyau Village, West Papua (A) The rings on the peduncle (yellow arrow) indicate the location of the previous inflorescences and that this plant has produced flowers nine times (B) Different shades of flower color from different plants of *H. pachyphylla* (C) a young leaf (D) a mature leaf (E) a mature plant with inflorescences

Table 1. Morphological comparison of *Hoya megalaster* and *H. pachyphylla*

Character	<i>H. megalaster</i>	<i>H. pachyphylla</i>
Young stem	Green	Light green
Old stem	Grey, cylindrical 3 mm in diameter,	cylindrical, stiff, 2-5 mm in diameter, green to greenish brown, glabrous;
New growth flush color	Reddish	Red mauve
Young leaf	Light brown, smooth surface	Dark brown, fine hair on the adaxial
Internode length	4-16 cm	10 to 25 cm
Petiole	Terete, 17-20 mm long, 3-5 mm diameter, green to brown color	Petiolate, 1-2 cm long and 3-5 mm in diameter
Lamina shape	Elliptic with entire leaf margin, thin, not succulent like most of the <i>Hoya</i> leaves, glabrous	Lamina ovate, fleshy, wavy on the edge, succulent
Leaf apices	Acute	Obtuse
Leaf bases	Rounded	Rounded
Leaf lamina	Broadly ovate, cordate at the base with the basal lobes often overlapping, 8 to 20 cm long and 5 to 6 cm wide, leaves have dimples between the veins, dark green in colour with lighter green venation.	Greyish green; 6.5 to 12 cm long, 3.5 to 7.5 wide, light green to red mauve on abaxial surface, light green on adaxial surface, apex acuminate, base rounded; venation palmate, visible vein on adaxial surface,
Longest part of leaf lamina	20 cm	12 cm
Midvein	Straight to slightly curved at the end; raised on upper surface.	Almost straight from the base to the apex; obviously raised on upper surface but less obvious at the apex.
Lateral venation	Moderately curved, 7-8 per side	Almost straight, not obvious compared to <i>H. megalaster</i>
Inflorescence	One per node, 6-10 flowers per umbel*	One per node, 30-40 flowers per umbel*
Corolla shape	Flat and saucer-shaped (concave), glabrous except the center of corolla covered with fine hairs, peduncle terete and 4-8 cm in length, corolla lobes are triangular in shape, incurved.	Reflexed, no hairs, peduncle terete and 5 to 10 cm in length. Color shades vary amongst the individual plants.
Corolla color	Dark red	Light yellow cream to light pink
Corona shape	Star-shaped, lobes are relatively thick, apex round	Star-shaped, lobes are apex round
Corona color	Dark red	Pale pinkish white with darker pink in center. Color shades vary amongst the individual plants

Note: *recorded from the first inflorescence during the first year of culture

The morphological identification that we conducted in this study provides information about the diversity of *Hoya* species in Papua that could be useful for further studies. These morphological characters can be used for future systematic studies that involved sequence (DNA) and non-sequence (morphology) data. It is hoped that the discovery of these two species that grew on the harvested/logged trees would provide awareness and encourage information campaign on the conservation of trees that are host to vulnerable, endangered and threatened species of plants and animals. Systems for the implementation of rules on the translocation and

commercialization of species, such as those of ornamental values, including Hoyas, should be in place. In the long term, biodiversity conservation and commercialization should both be working so as to promote the economic development of biodiverse areas, such as Papua.

5. CONCLUSION

Our study had described the main morphological characters of leaf, stem and flowers of the two native Hoyas from a remote area of Papua, *H. megalaster* and *H. pachyphylla*. The morphological identification that we conducted in

this study has provided more information about the diversity of *Hoya* species in Papua that could be a useful addition to the known *Hoya* species and for further studies. The morphological identification would provide useful and practical information prior to confirmation using PCR assay in the laboratory.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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