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The Hoyas of Sabah, A Commentary with Seven New Species and a New Subspecies

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Summary. The genus *Hoya* R.Br. has about 200 recognised species. There are however, more than 500 species names in The International Plant Names Index (IPNI), with many new species described from Borneo over the past ten years. Based on fieldwork and studies of living collections over the last ten years, it would appear that there are now about 60–70 species in Sabah alone, including the seven new species and one new subspecies described in this paper, with further species still to be assessed. The new species described here add many unusual features compared to other described species in the genus, and so they provide important details for a fuller understanding of the diversity of species in the genus, contributing valuable information towards the future sub-division of the genus into sections, and once molecular work is done to place them into the appropriate clades. The seven new species and one new subspecies are *Hoya benchaii, H. chewiorum, H. hamiltoniorum, H. kipandiensis, H. linusii, H. retrorsa, H. sammannaniana* and *H. sigillatis* ssp. *paitanensis*.

The State of Sabah in Malaysia, which forms just under 10% of the area of the northern part of the island of Borneo (73,619 km^2 out of 746,000 km^2 for the whole of Borneo) has, based on specimens in the Sandakan Herbarium of the Forest Research Centre (SAN) and Sabah Parks Herbarium (SNP), and several living collections, especially at Kipandi Park, an estimated 60–70 species, many of which remain unnamed. Seven of these species and one subspecies are named in this paper, with more expected as studies progress. Considering that there are more than 500 species names under *Hoya* in the International Plant Names Index (2014), it is reasonable to expect that a comprehensive assessment of the diversity will take some time. We therefore include various commentaries and ecological observations that, hopefully, will provide as much information as possible on this interesting genus.

In the last ten years after setting up a collection of 25 species of native *Hoya* at the Agricultural Park in Tenom, Sabah, at 200 m altitude, further interest in the native species of Sabah resulted in descriptions of several new Bornean species by Green (2001, 2004) and Kloppenburg (2001, 2002).

The much larger collection at Kipandi Park at 700 m in the Crocker Range was established by Linus Gokusing over the last six years. Because of the cooler temperature, more hill and montane species were established and studied. It was earlier thought that there were thirty species in Sabah, however, Kipandi Park now has a collection of over sixty species, many probably undescribed, and including the seven new species and one new subspecies described in this paper.

The Forest Research Centre at Sepilok also maintains a further living collection of lowland native *Hoya* at its Rainforest Discovery Centre.

The ‘wax’ or ‘porcelain’ flowers, or ‘milkweeds’, as hoyas are often referred to, are now popular indoor plants, grown in many countries, especially in Europe (particularly Sweden), North America and Australia, where many *Hoya* societies have been formed. More recently, they have become popular for planting both in gardens, and as house plants, in Asia. The genus was named after Thomas Hoy by Robert Brown (1810), with *H. carnosa* (L.*f.*) R.Br. as the type. Hoy was, at the time, the gardener at Syon Park, near Kew Gardens in England, where he looked after a large collection of tropical plants in the glasshouses of the Duke of Northumberland.

The measurements for the description of the new species here are taken from cultivated plants grown from material established at Kipandi Park (Kipandi Butterfly Park and Native Plant Gardens) in Sabah. The type specimens were subsequently collected from these cultivated plants, and deposited with the herbaria of the Forest Research Centre at Sandakan and the Sabah Parks.

At present, molecular work is ongoing to delimit *Hoya* as a monophyletic genus distinct from its closest relatives in the tribe Marsdenieae (Wanntorp *et al*. 2006a & b, Wanntorp &

Forster 2007, Wanntorp & Kunze 2009, and Wanntorp & Meve 2011). However, additional molecular sampling is still needed for many of the 200 or more recognised species. Because of this, and the fact that previous classifications of *Hoya* were based on morphological characters (Burton 1985, 1995 & 1996) that may not have been comprehensively studied, we do not attempt to place any of these new species into a sectional classification.

Ecology

We provide some basic information (including altitudinal range and soil) for each species. We generally consider lowland forest as three categories: true Lowland Forest reaching 200 m in altitude, Hill Forest from 200 to 600 m, and Upper Hill Forest from 600 to 1200 m. Above this is Lower Montane Forest from 1200 to 1800 m with a much reduced number of *Hoya* species recorded, and Upper Montane Forest from 1800 to 2800 m, where *Hoya* species are rare. Between these forest categories, there are often intermediate zones of about 100 m, or more, where one category grades into the other.

Besides these main categories, we also recognise the distinctive vegetation growing on deep sandy substrates (*kerangas* or tropical heath), over soils derived from ultramafic rocks, and others.

Several *Hoya* species, however, have ranges that include two or more forest categories, e.g., *H. telosmoides* Omlor occurs in upper hill as well as in lower montane forest, and *H. imperialis* Lindl. in lowland coastal heath forest and riverine forest as a terrestrial climber, and as an epiphytic climber in hill forest, in Kinabalu Park.

Some vegetation types can be particularly rich in *Hoya* species, one example being the heath forest in Sabah at Nabawan, in a hill forest formation at 450 m, where one of us (Lamb) has observed and collected eleven species of *Hoya*: including *H. acicularis* T. Green & Kloppenb.; *H. forbesii* King & Gamble, *H. ignorata* T.B. Tran, Rodda, Simonsson & Joongku Lee (2011); *H. kloppenburgii* T. Green (2001); *H. lambii* T. Green, *H. mitrata* Kerr; *H. nabawanensis* Kloppenb. & Wiberg; *H. obtusifolioides* T. Green & E. Gilding; *H. scortechinii* King & Gamble; *H. sigillatis* T. Green (2004) and *H. waymaniae* Kloppenb. In this heath forest, several species of *Hoya* and *Dischidia* R.Br. have an association with ants, as noted by Kleijn & Donkelaar (2001) and are also recorded in ant gardens. *Hoya mitrata* and *Dischidia major* (Vahl) Merr. and *D. imbricata* (Blume) Steud. have leaves that form shell-shaped leaves in clusters, which together form shelters for ants in the Nabawan heath forest. *Hoya ignorata* is a species in which ants have most likely carried the seeds into a hole in a branch or tree trunk, from which the plant grows out, forming a small epiphytic shrub. As many *Hoya* species are commonly found as terrestrial climbers along streams and river banks, where they are easier to access, this does not always provide a complete picture of the habitat of these species.

As much of the lowland and hill forests in Sabah have tree canopies from 20–50 m tall, it is extremely difficult to spot or collect those species that are epiphytic shrubs or climbers. It appears that this canopy habitat, especially in hill forests, has a very high diversity of various epiphytic plants such as orchids, ferns, and related *Dischidia* species and is probably far richer in *Hoya* also. One of the new species described here, *H. sammannaniana*, has been found as an epiphytic climber in Sabah, but as a terrestrial riverine climber in Kalimantan.

Distribution and Conservation Status

The eight taxa described in this paper have either been recorded from a very restricted locality, represented by very few specimens, or from very widely distributed locations within Sabah, and in one case as far as South-west Kalimantan. Based on the known localities of the specimens, we were able to determine whether it falls into a Conservation Area, such as a National or State Park, or a Forest Reserve and hence, indicate whether it may be threatened in the wild. However, as exploration and collecting progresses, there is a possibility that what we interpret as localised species could be found further afield.

Conservation assessments are made following IUCN criteria (IUCN 2001), with nine categories, and five criteria (A–E) used for assessing taxa falling into the categories Critically Endangered (CR), Endangered (EN) and Vulnerable (VU). These assessments are given under the conservation status provided for each of the eight taxa described in this paper.

A Commentary on the Morphological Characters of *Hoya*

The species of *Hoya* found in Sabah are often herbaceous climbers, ascending or scrambling over, vegetation from the ground, commonly along river banks. They can also be found as epiphytic shrubs or climbers in the canopy. A small group of species in Sabah have a distinct association with ants, as it appears the ants carry the seeds into holes in the tree trunks or branches which are rotten or hollow inside, where the seeds germinate. This group includes some of the smallest epiphytic shrubs. In some cases it was found that the ants carry aphids into the holes in the branches, where they feed on the *Hoya* roots and in turn, are milked by the ants (pers. obs. A. Lamb), who observed it in *H. spartioides* (Benth.) Kloppenb., which is close to the new species, *H. retrorsa*, described here, which also has only been found growing out of holes in the trunks or branches of understorey trees.

Morphological characters used to separate *Hoya* species are as follows, and are referred to in diagrammatic drawings in Fig. 1 (A–E) and Fig. 2 (A–L).

Many *Hoya* species have twining stems. Some also have pendulous stems hanging down from the forest canopy. Some species are epiphytic shrubs or climbers. Most species have milky-white sap. The stems in older vines often become corky with a buff-brown to grey-

coloured bark. Adventitious roots can arise, both at the nodes and along the internodes; the latter can be glabrous or hairy (Fig. 1A, 1–3).

The leaves are arranged in pairs, opposite each other, at the nodes along the stem, where the extra-axillary penduncles of the inflorescences also occur. Most species have petiolate leaves, the petioles are often twisted, some are grooved on the upper surface or rounded, and can be glabrous or hairy (Fig. 1A, 4a & 4b). The lamina varies greatly in shape, size and thickness; the surfaces can be glabrous or hairy, leaf venation is sometimes visible, sometimes not (Fig. 1A, 5). The shapes of the lamina can be varied and are commonly elliptic, often oblong, lanceolate to ovate with some species with a round or spathulate lamina (Fig. 1A), or rarely, linear (Fig. 1A, 7) as in *H. acicularis*, to terete as in *H. retrosa*. Lamina texture can vary from succulent to thick in sunny exposed positions, to thinner in shaded habitats; lamina size can also vary due to light and exposure, becoming smaller in sunny positions and larger in deep shade. The lamina surface can sometimes have various markings on the upper surface such as blotches, spots or streaks and can be glabrous or hairy either on both surfaces or on the adaxial or abaxial surface only. The lamina base and apex can also be distinct with the bases varying from obtuse or cordate to acute, and the apex commonly acute or acuminate to obtuse or rounded (Fig. 1A). The lamina venation falls into two main groups, the most common being pinnate-veined, where the veins branch off from the midrib laterally at intervals along most of the midrib, and can be at an acute angle to the midrib, or at right angles, and most form loops near to the lamina margins (Fig. 1A, 5a & b). Looping connections are sometimes referred to as anastamosing venation. Examples are *H. fraterna* Blume (1849) and *H. danumensis* Rodda & Nyhuus (2009). These veins can also form a further network between the loops, forming a netted venation. In palmate venation, several main veins, together with the midvein, arise from the base of the lamina in a combination of three, five or sometimes seven veins (Fig. 1A, 6a–6c), examples being *H. verticillata* (Vahl) G. Don. and *H. glabra* Schltr.

The inflorescences arise alternately on both the upper or lower surface of the stem nodes, and most have peduncles that can be nearly sessile, or variable in length, and are hairy or glabrous (Fig. 1A, 8 & 9). Most species have persistent penduncles that continue producing single flowers, or umbels of flowers, from a rachis (Fig. 1A, 11), that lengthens with age from 1 mm, with the first flowers, to over 9 cm as observed in *H. verticillata* (AL 2202/2011, SAN). Other species have peduncles that abort after flowering, and follicle (seed-pod) production. An example is *H. burmanica* Rolfe, a species from Myanmar and often also in *H. obtusifolioides*, a Sabah species. Most Sabah species have peduncles that are positively geotropic with either flat, concave or convex umbels. Several species, such as *H. mitrata,* and the new species *H. hamiltoniorum* described here, have negatively geotropic inflorescences, with the peduncles erect or laterally held, with only flat to convex to globose umbels of flowers (Fig. 1A, 10 a & b). Relatively few species have peduncles that have only one to two flowers per inflorescence (characteristic of several *Dischidia* species), as can be seen in the newly described *H. mappigera* Rodda & Simonsson (2011c), from Peninsular Malaysia

and southern Thailand and recently discovered by one of us (Linus Gokusing) in Tawau District (*Linus Gokusing* in Lamb, AL 2316/2012). Also, the new species described here as *H. retrorsa,* with single flowers, and *H. sammannaniana* with one or two flowers, usually open at separate times (Fig. 1A, 9b).

The flowers that occur in umbels, as opposed to singly, have pedicels that are either hairy or glabrous (Fig. 1A, 12a & b and Fig. 1C, 1 & 2). Where all the flowers have pedicels of the same length, an umbel that is flat, convex to globose in shape, is produced (Fig. 1A, 13

Fig. 1. Diagramatic representation of the morphology of *Hoya* plants, inflorescences and flowers.

The diagrams (not drawn to scale) represent morphological features useful for identifying or describing a small range of species from the Malesian region.

A. Stems, leaves and inflorescences.

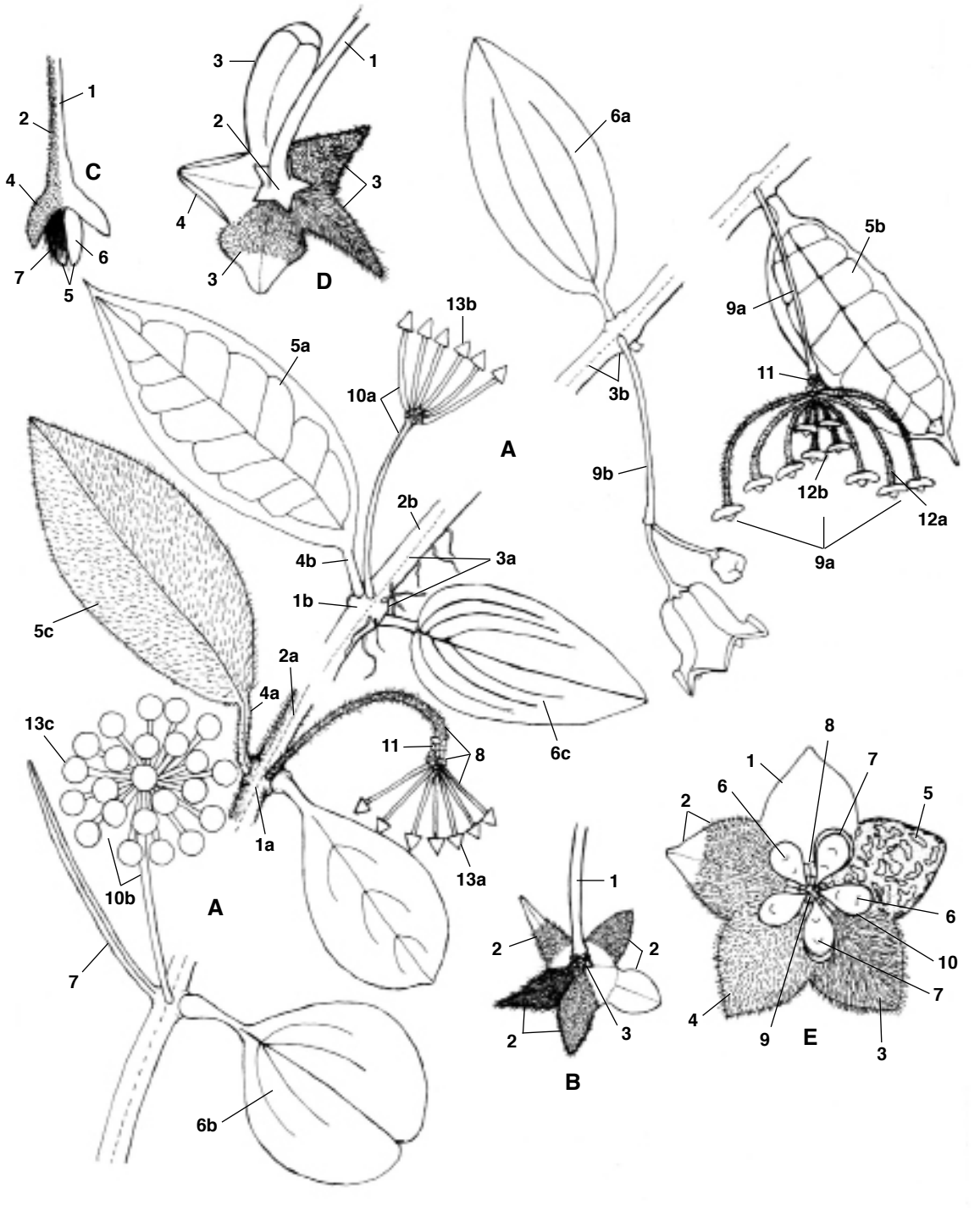
1. Node, a) pubescent; b) glabrous.
2. Internode, a) pubescent; b) glabrous.
3. a) adventitious roots at nodes and internodes.
   b) no adventitious roots at nodes or internodes.
4. Petiole, a) grooved and hairy; b) round and glabrous.
5. Leaf lamina, a) pinnate-veined, secondary veins at acute angle to midvein, glabrous;
   b) pinnate-veined, secondary veins at right angles to midvein, glabrous;
   c) indistinct secondary veins, pubescent.
6. Leaf lamina, a) palmate veined with midvein and two main secondary veins.
   b) palmate with midvein and four main secondary veins.
   c) palmate with midvein and six main secondary veins.
7. Leaf lamina terete, grooved on adaxial surface.
8. Positively geotropic inflorescence with pubescent peduncle and convex umbel of flowers.
9. Positively geotropic inflorescences with a) concave umbel of flowers.
   b) 1–2 flowers per inflorescence.
10. Negatively geotropic inflorescence with a) flat umbel of flowers;
    b) globose umbel of flowers.
11. Rachis on persistant peduncles.
12. Inflorescences concave with a) long curved pubescent pedicels;
    b) short curved pubescent pedicels.
13. Inflorescences with straight, equal length pedicels a) convex umbel of flowers;
    b) flattened umbel of flowers;
    c) globose umbel of flowers.

B. Pedicel, calyx and colleters.

1. Pedicel.
2. Calyx sepals showing different shapes and pubescence.
3. Colleters occurring within the inner part of the calyx.

C. Pedicel, calyx and ovary.

1. Pedicel glabrous.
2. Pedicel pubescent.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3. Calyx Glabrous.
4. Calyx pubescent.
5–7. Ovary bi-carpellate with (6) glabrous ovary; (7) hairy ovary with glabrous apex.

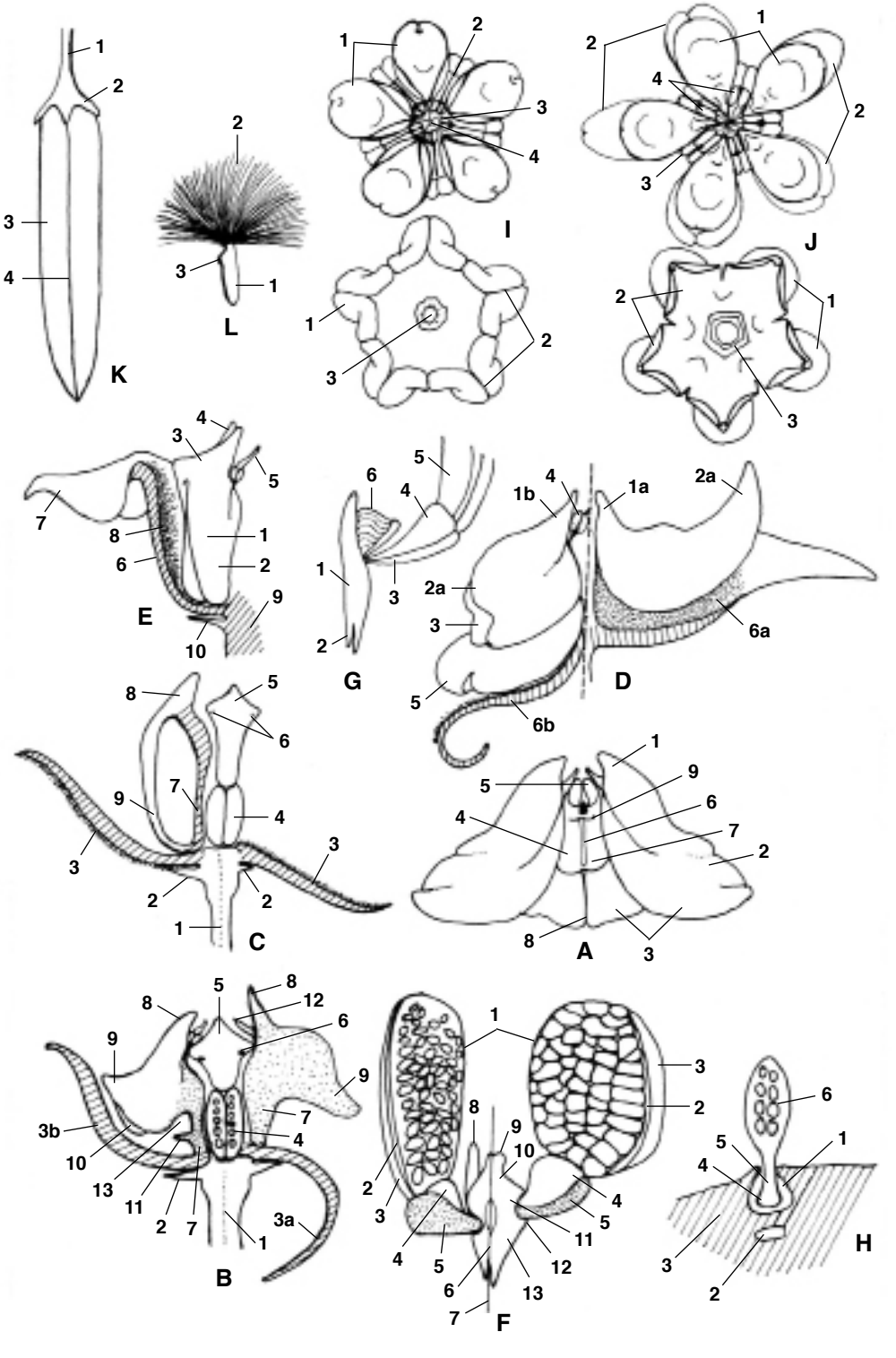
D. Pedicel, pentamerous calyx and different shapes and indumentum of the corolla lobes.
1. Pedicel.
2. Calyx.
3. Corolla lobe shapes and pubescence.
4. Corolla lobe margin revolute.

E. Flower from above showing corolla lobes with different surfaces and coronal stamina.
1. Corolla lobe glabrous.
2. Corolla lobe glabrous.
3. Corolla lobe with long hairs.
4. Corolla lobe with fine pubescence.
5. Corolla lobe with coloured markings.
6. Coronal lobe.
7. Coronal lobes with skirt.
8. Anther wings.
9. Pollinarium.
10. Apical anther tissues.

Fig. 2. Diagrammatic details of flower, calyx, corolla, corona, pollinia and follicles of *Hoya*.

A. The corona from the side showing two coronal lobes.
1. Inner process.
2. Outer process.
3. Anther skirt.
4. Anther wings.
5. Pollinarium.
6. Guide rails.
7. Entrance to guide rails.
8. Groove between anther skirt.
9. Top of guide rails opposite the stigmatic surfaces on the inside.

B. Diagrammatic cross-section of flower.
1. Apex of pedicel.
2. Calyx lobes.
3. Glabrous corolla lobes a) reflexed; b) forming a bowl.
4. Bi-carpellate ovary.
5. Conical stigma head.
6. Stigmas on underside of stigma head opposite the top of the guide rail.
7. Column (filament tube).
8. Inner process.
9. Outer process.
10. Coronal groove.
11. Annular corona.
12. Anther appendages.
13. Secondary nectar glands.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C. Diagrammatic cross-section of flower with an erect coronal lobe.

1. Pedicel.
2. Calyx lobes.
3. Corolla spreading or saucer-shaped with pubescence on either the abaxial or adaxial surfaces.
4. Bi-carpellate ovary.
5. Conical stigma head.
6. Stigmatic area.
7. Column.
8. Inner process.
9. Outer process fused to the base of column.

D. Diagrammatic cross-section to show different coronal lobes with and without skirts in relation to the corolla.

1. a) Inner process lower than outer process, no skirt;
   b) Inner process higher than outer process, with skirt.
2. a) Outer process higher than inner process.
   b) Outer process bulbous and lower than inner process with lower edge joined to a coronal skirt..
3. Coronal groove.
4. Position of pollinarium.
5. Coronal (or anther) skirt, hiding base of column.
6. Corolla lobes a) Corolla spreading with pubescence under the corona, lobes glabrous, base of column visible below lobe;
   b) Corolla pubescent on adaxial surface apex revolute and glabrous on adaxial surface, base of column hidden.

E. Diagrammatic cross-section of campanulate flower with cup-shaped base.

1. Coronal lobe.
2. Outer process.
3. Inner process.
4. Inner process with bifid apex.
5. Anther appendage.
6. Base of corolla cup-shaped.
7. Corolla lobe glabrous.
8. Corolla base with hairs on the inside.
9. Pedicel.
10. Calyx lobes.

F. Diagrammatic representation of pollinarium, divided to show different shapes of pollinia, caudicles, translators and retinaculum.

1. Different shaped pollinia.
2. Pellucid edge.
3. Crest of pellucid edge (called pollinia wings in the past).
4. Caudicles.
5. Translators.
6. Retinaculum.
7. Retinaculum with bifid end.
8. End on view of retinaculum wing.
9. Retinaculum head.

10. Neck.
11. Shoulder.
12. Waist.
13. Hip.

G. Retinaculum wing (seen very rarely).
1. Retinaculum.
2. Bifid end.
3. Translator.
4. Caudicle.
5. Base of pollinia.
6. Side view of retinaculum wing.

H. Diagrammatic view of cross-section of pollinia transported into guide line, end on.
1. Guide rail.
2. Nectar tube.
3. Anther wing.
4. Crest of pollinia (referred to as a wing in the past).
5. Pellucid edge.
6. Pollinia.

I. Diagrammatic view of corona without skirt, from —
a) above: 1. Coronal lobe.
2. Anther wings.
3. Pollinia.
4. Anther tissues on top of conical stigma head.
b) below: 1. Coronal lobe.
2. Coronal groove.
3. Tissue around column (filament tube).

J. Diagrammatic view of a corona with a skirt from —
a) above: 1. Coronal lobes.
2. Coronal skirt (indicating different shapes).
3. Anther wings.
4. Pollinia.
b) below: 1. Outer lobe of coronal lobe.
2. Anther skirt.
3. Tissue of the column (filament tube).

K. Follicle — Seed pod.
1. Pedicel.
2. Calyx lobes.
3. Seed pod.
4. Suture where pod opens when ripe.

L. Seed.
1. Fusiform seed.
2. Coma (tuft of hairs acting as a parachute for wind dispersal).
3. Minute wing seen on seeds in some species.

a–c). Where the pedicels are shorter for the flowers in the centre of the umbel, and become longer and curved, for the flowers further away from the centre, the umbel becomes concave in shape (Fig. 1A, 12a & b).

The flowers of *Hoya* are pentamerous and composed of three parts: calyx, corolla and corona. Of lesser prominence in studying the characteristics of the flowers are the pedicel (Fig. 1B, 1; 1C, 1–2; 1D, 1), and the pentamerous calyx which often is referred to as calyx lobes (or sometimes called sepals) in this paper. The calyx lobes, which are generally free, are hairy or glabrous, some long and narrow, or short and broad, with rounded to obtuse or acute apex (Fig. 1B, 2 & 1D, 3–4), and in some cases have colleters, which are finger or hair-like secretory glands (Fig. 1B, 3) present at the base of the calyx and pedicels, sometimes producing nectar.

Seated in the calyx is the bi-carpellate ovary (Fig. 1C, 5–7). When flowers are examined, the corolla with corona, is easily separated from the pedicel and calyx, together with the two carpels (ovaries), and photographed together for the descriptions in this paper. The length and shape of ovaries are noted as well as, and whether or not the ovaries are glabrous, pubescent or hairy. It would appear over 90% of *Hoya* ovaries are glabrous, and in Sabah, only in the new *H. hamiltoniorum* are they hairy, resulting in hairy follicles. In *H. obtusifolioides*, the follicles are minutely pubescent, but the ovaries appear glabrous. As the carpels come together with the pedicels and calyx in our photographic and botanical illustrations, we have decided to cover their description at this point, rather than separate them, (as is usually done), describing the carpels before the follicles and after the pollinarium in the species descriptions.

Hoya species have flowers in which the petals are fused at the base to form a corolla, but most species have free corolla lobes. The corolla can vary in shape, from saucer-shaped, commonly campanulate, e.g., *H. archboldiana* C. Norman from New Guinea, to globose, e.g., *H. heuschkeliana* Kloppenb. from the Philippines, and some with nearly urn-shaped or tubular flowers, e.g., *H. telosmoides* Omlor, and one of the new species, *H. sammannaniana* (Fig. 1A, 9b). A few have the lobes free to very near the base of the corolla as in the new species *H. kipandiensis* and *H. retrorsa*. A few species like *H. danumensis*, have the corolla lobes joined up to the apices forming a saucer. The colour of the flowers varies a lot from yellow or white flowers to purple or reddish, and even green with corollas having one colour or different colours on the free lobes. Some flowers may have spots on the corolla. The flowers when fully open, can have their corolla lobes spreading, reflexed to revolute (Fig. 2D, 6a & b), and in some species the lateral margins of the lobes are revolute (Fig. 1D, 4). The surfaces of the corolla and the lobes can be pubescent to long hairy or glabrous (Figs. 1D, 3 and 1E, 1–4), on either the abaxial (outer) or adaxial (inner) surfaces, or partly so that the basal area is hairy and the apices of the lobes glabrous (Fig. 1D, 3 & 1E, 2). In some species, the base of the corolla under the corona can be extremely hairy as in the new species *H. hamiltoniorum* (Fig. 2D, 6a).

The five lobes forming the most distinctive feature of the corona, in the centre of the flower, are actually attached to the backs of the fused stamens at the anthers (Figs. 1E & 2A). As such the corona is often described as staminal, alluding to its origin or attachment. Each lobe consists of an inner projection (often erect), the inner process (lobe) and an outer, more bulbous process (lobe), which has revolute margins, forming the basal lobe grooves (often previously called coronal grooves). The distinct shapes of these coronal lobes in the different species, is one of several defining characters separating the species. In some species the outer process (basal lobe) has a skirt underneath, sometimes making the corona wider or longer, and often obscuring the base of the column (Figs. 1E, 7; 2A, 3 & 2D, 5).

The genus *Hoya*, like other Asclepiadoideae members, has stamens fused to each other, and to the conical head of the style, forming a rigid conical gynostegium, which includes the staminal corona. The fused filaments of the stamens form a tube, referred to as the column (or filament tube, by some authors), the base surrounding the bi-carpellate ovary (Figs. 2B, 7 & 2C, 7). Each anther has two pollinia (with pollen grains enclosed in pollen sacs as in the orchids). One pollinium from each adjacent anther is united by a translator apparatus to the central retinaculum (also referred to as a corpuscle). The whole is referred to as a pollinarium (Fig. 2F). The pollinarium (Fig. 2F), consists of a pair of pollinia (pollen sacs), caudicles and translators, with the retinaculum, clearly visible as a dark, usually brown dot. Below the pollinarium are the guide rails created by the adjacent wings or edges of the anthers, also referred to as the anther wings; and at the top of each guide rail (Fig. 2A, 6), just below the pollinarium, is an opening to one of the five receptive stigmatic areas (Fig. 2A, 9) on the lower surface of the stigma head and positioned behind each guide rail, which alternates with the anthers (Fig. 2B, 6). The entrance to the guide rails between the anthers (Fig. 2A, 7), is where the visiting insect dislodges the pollinium into the guide rail, so that they are near the opening to the receptive area of the stigma. Each pollinium (Fig. 2F, 1) containing many pollen grains often has a pellucid edge, often clear, on the outer edges of the pollinia (Fig. 2F, 2), sometimes thickened to form a crest or narrow wing (Fig. 2F, 3), (which Rintz (1978) referred to as the pollinia wing). The caudicles attached to the pollinia and the retinaculum usually are a clear grey colour under the microscope (Fig. 2F, 4), and often bounded by a narrow to broad translator, often narrow to scapula-shaped or winged (Fig. 2F, 5). Both these structures tie the pollinia to the brown retinaculum (Fig. 2F, 6), which is the body that forms a clamp round the tarsi, or around the proboscis, of a visiting insect. The shape of these translators, caudicles and the retinaculum is also used to note differences between species, with some retinacula having a distinct head, shoulders, waist, hip and bifid end (Fig. 2F, 9–13) (Kloppenburg 1999). Rarely, the retinaculum also has wings attached at about the hip (Figs. 2F, 8 and 2G, 6) as found in *H. kipandiensis,* one of the new species described in this paper. The retinaculum acts like a 'clamp' so that when the correct-sized insect visits a flower, the tarsi (bristles) on the 'feet' of the insect's legs, get caught in this 'clamp', so that when it flies off, it pulls off the pollinarium and transports it to the next flower. In some cases, the proboscis of the insect, when seeking out nectar, may also get caught. At the next flower, it often gets rid of the pollinarium by pulling it along the guide rails (Kunze

& Wanntorp, 2008) (Fig. 2A, 6), that are formed by the differentiated parallel margins of the anther, (revolute edges of the adjacent coronal lobes, called previously anther wings) (Fig. 2A, 4). The pollinia are dislodged, just over the opening to one of the five receptive areas of the stigma, on the underside of the stigma head (Figs. 2A, 9 & 2B, 6). Kunze & Wanntorp (2008) and Wanntorp & Kunze (2009), have covered in more detail the anatomy of the guide rails of the corona (Fig. 2A, B & H), and nectar tunnels in some species of *Hoya* and *Dischidia,* showing that insects pull the pollinarium into the entrance of the guide rails (Fig. 2A, 7), with the pellucid edge 'slotting' into a guide rail so that the pollinia sits above it with a nectar tube lying under the guide rail (Fig. 2H). For species with no pellucid edge on the pollinia, it would appear the whole pollinia is pulled between the guide rails. The nectar in the nectar tunnel probably induces pollen grains to germinate, for when we placed a pollinarium in a dilute solution of water and honey overnight, a mass of pollen tubes had grown through the pellucid edge by morning.

In the pollinium sacs which have lateral pellucid margins, the germinating pollen tubes carrying the germinating pollen nucleus grow out from the pellucid margin, through the anther tissue to the stigma, and then down through the stigma head tissue to the two carpels (ovaries) referred to as the bi-carpellate ovary, and fertilization is achieved by the fusion of the two haploid nuclei (one from the pollen tube and the other from a single ovule), if there is genetic compatibility.

The nectar from the nectar tube (Figs. 2A, 6 & 2H, 2), continues down a groove below the guide rail (Fig. 2A, 8), and collects at the primary nectar source for the visiting insects. This is usually on the corolla surface between the outer coronal lobes or skirts. In one species, *H. curtisii* King & Gamble, from Peninsular Malaysia and Borneo, this nectar accumulates on an annular corona, a ring of tissue around the column, derived from the fusion of the anther skirt (Fig. 2B, 11). However, none of the new species described here has an annular corona, however, in Borneo, *Hoya medinillifolia* Rodda & Simonsson (2011b), originally described without an annular corona from old dried specimens from Sarawak, was found to have an annular corona when it was discovered in flower in Sabah in 2013. A secondary source of nectar is also produced in some species from nectar glands on the column underneath the corona lobes or coronal skirts (Fig. 2B, 13). We have not looked for the presence of secondary glands in the new species described in this paper.

Once the pollen grains have germinated, and the pollen tubes have grown out from the pellucid edge, down through the stylar tissue to fertilise the ovaries (twin carpels), as Rintz (1978) explains, often only one ovary develops into a follicle (seed pod) (Fig. 2K), and the other aborts. Only rarely do two follicles develop, as can be seen in Fig. 43. Twin mature carpels have been seen in the wild by the authors on species such as *H. imperialis*, *H. lasiantha* Korth *ex* Blume, and *H. obtusifolioides*. When the ovaries are fertilised, according to Rintz (1978), the follicles can reach their full size in a month, but do not mature until two to three months after fertilization. In some cases the maturation could be one year long (seen on *H. carnosa*).

The follicles in many species of *Hoya* are long and thin (as seen in Figs. 56, 71 & 85 for the new species, *H. kipandiensis*, *H. linusii* and *H. retrorsa*), and tightly packed with seeds. When mature, the follicle splits open along a single line or suture (Fig. 2K, 4), and as the fusiform seeds dry out they are pushed up and outwards and borne off on air-currents (Fig. 3), floating like a parachute on the plume of hairs (coma) (Figs. 3 & 4), into the forest canopy or along a river course until they land on a branch or tree-trunk, or in organic matter on the forest floor along the river banks. In a few species of *Hoya*, quite large follicles (more than 10 cm × 4 cm), are produced, due to an outer thick spongy pericarp, which may help to protect the seeds from insect attack such as in the Sabah species, *H. obtusifolioides*, and *H. imperialis* (Fig. 4). In the *Hoya* species described here, only three were found with follicles.

Fig. 3. Close-up of seed in 'flight' on its 'parachute' or coma. Photo: Anthony Lamb.

The seeds are fusiform, long and slightly flattened, some with reduced wings (Figs. 2L, 1 & 3), or the wings may be absent, and an apical tuft or plume of hairs called a coma. *Hoya omlorii* (Livsh. & Meve) L. Wanntorp & Meve, from Sarawak, is a species that was previously placed in the genus *Clemensiella* Schltr., that has such a reduced wing. The coma, on drying, spreads the hairs into a plume to form a parachute for wind dispersal (Fig. 2L & Figs. 3 and 4). The seed coats are hygroscopic when dry, but quickly absorb moisture on landing in damp moss, bark or organic matter, and germinate almost immediately.

Some *Hoya* species are strongly scented at night, producing droplets of nectar at the base of the corona to attract pollinating insects such as moths. Studies of the pollinators have not been done in Sabah, though day-time and night-time moths (Figs. 5 & 6), honeybees and ants have been seen on some species. Honey bees (*Apis cerana*) and especially ants seem to be 'mopping up' the left-over nectar and do not appear to be pollinators. The authors have noted small moths on *Hoya fraterna* Blume (Fig. 6) in the wild in the Crocker Range, and a day-time moth on the flowers of *Hoya* aff. *australis* R.Br. *ex* Traill (Fig. 6), in which the legs

Fig. 4. A mature follicle of *Hoya imperialis*, showing the tightly packed seeds and some seeds being carried off, on a tuft of hairs, or coma, on the air currents. Photo: Anthony Lamb.

of the moth fitted exactly to the retinaculum. Some scents are quite distinct, and could be utilised in distinguishing some species if they could be accurately described.

In collecting species of *Hoya*, very few pests were noted feeding on the leaves, which is partly due to the poisonous nature of the white sap, except in the Crocker Range, where caterpillars were seen (Figs. 7 & 8) on the leaves of *H. chewiorum,* described in this paper.

A full understanding of all the characteristics of the plants and their inflorescences is key to determining the differences between the species, and is covered in the descriptions of the new species that follow.

Fig. 5 (left). The daytime moth *Auriculocery pterodactyliformis* Holloway, on the flowers of *Hoya* aff. *australis*. Photo: Jamirus Jumian. **Fig. 6** (right). A species of *Trabala* in the family Lasiocampidae, probably *Trabala shira* Roepke (based on Holloway 1987), on the flowers of *Hoya fraterna*, at 800 m in the Crocker Range. Photo: Gina Hamilton.

Fig. 7 (left). The caterpillar of *Ideopsis guara perakana* Fruhstorfer, in the family Danaidae, on the leaves of *Hoya chewiorum* , in the Crocker Range. Photo: Anthony Lamb. **Fig. 8** (right). The pupae of *Ideopsis guara perakana* on the leaves of *H. chewiorum* . Photo: Steven Chew.

The New Taxa Described

1. Hoya benchaii *A. Gavrus, A. Lamb, B. Emoi & L. Gokusing* **sp. nov.**

Hoya kloppenburgii T. Green similes sed plantae folium ovatum 8–14 cm longa, 5–7.5 cm lata, margo crasso distincto (nec lanceolatum 10–21 cm longa, 4–5 cm lata margo gracilis crenatus), pollinarium translator scapulatum (nec lunatus), pollinium brevis 0.59 longum × 0.17 mm latus (nec 0.66 mm longum × 0.23 mm latus), differt. Typus: Ben Chai in Lamb AL 2132/2011, Borneo, Malaysia, Sabah, east of Ranau, Telupid area, 8th May 2011, cultivated at Kipandi Park, accession no. H 37 (holotypus SAN; isotypus SNP). **(Figs. 9, 10, 12 & 14–18)**

Moderately robust epiphytic climber, 4–5 m high; sap milky-white in all parts. **Stem** terete, 2–5 mm thick, glabrous; internodes 7–15 cm long, nodes slightly enlarged, adventitious roots developing along internodes. **Leaves** opposite; petiole curved, terete, green (when fresh), becoming corky with age, 1–3 cm long, 0.4–0.5 cm thick, glabrous; lamina ovate, thick, stiff, 8–14 cm × 5–7.5 cm, adaxial surface often blotched red in the sun, glabrous, abaxial surface light green, sometimes red in the sun, base rounded, apex acute, margin thickened, 1.5–2 mm thick; pinnate-veined, secondary veins obscure, 35°–45° to midvein, along most of the mid-vein, forming loops near the margin. **Inflorescence** positively geotropic, a concave umbel of 4–11 flowers, faintly fragrant at night; peduncle erect-vertical to angled downwards, persistent, 5–14 cm long, 0.2–0.4 cm thick; rachis producing a series of flowers, extending up to 1.5 cm long (Figs. 9A & B, 10 & 12). **Flowers:** pedicels green to purple with darker spots and streaks, outermost up to 3.3 cm long, curved, the central shorter, around 0.9 cm long, *c*. 0.1 cm thick, glabrous; calyx pentamerous, 5–8 mm diameter; calyx lobes deltoid, purple, 1.8–2.2 mm × 1.4–1.5 mm, glabrous on both surfaces, apex acute; ovary bi-carpellate, obclavate, pinkish, 1.8–2.1 mm high, 1.6–1.8 mm at base, glabrous (Figs. 9C, F–H, & 14); corolla cream or apricot to pinkish-red, 1.0–1.1 cm diameter, margin

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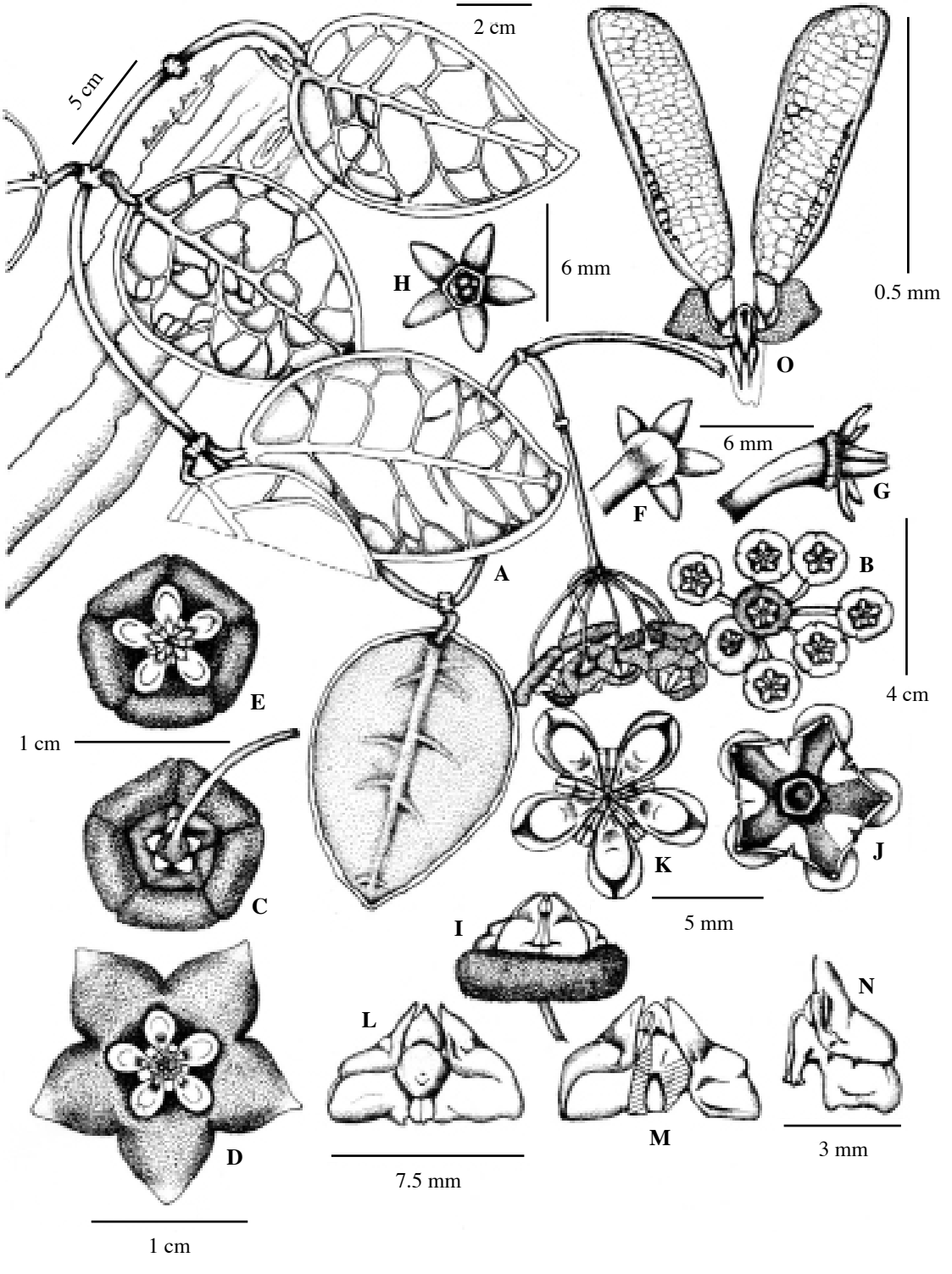
Fig. 9 (opposite). ***Hoya benchaii***. Botanical drawing by Bellia Emoi, based partly on *Ben Chai* in Lamb *AL 2132/2011*, and living type plant material, prior to pressing, cultivated at Kipandi Park, accession no. H 37. **A.** Flowering branch with positively geotropic peduncle with concave umbel of flowers. **B.** Inflorescence from below. **C.** Flower from above, showing pedicel, calyx lobes and revolute lobes of the corolla. **D.** Flower with corolla lobes flattened out, showing the central corona and minutely pubescent corolla with glabrous apices. **E.** Flower with corona and corolla with revolute lobes. **F.** Apex of pedicel with glabrous calyx lobes. **G.** Apex of pedicel from the side, showing calyx lobes and bi-carpellate ovary. **H.** Calyx lobes from above with glabrous bi-carpellate ovary. **I.** Side view of flower showing pubescent corolla with revolute margin. **J.** Corona from below showing the skirt. **K.** Corona lobes, pollinia and anther wings from above. **L.** Shape of the corona lobes from side view, and the distinct skirt under the lobes. **M.** Cross-section of the corona, showing inner and outer processes, the position of the pollinarium, the ovary and the stigma head. **N.** Single corona lobe attached to the back of the anther, showing the skirt under the outer process. **O.** Pollinarium, pollinia with pellucid edges, which have a bump near the base, caudicles (clear) and large, triangular translators (stippled), attached to the retinaculum.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revolute; corolla lobes fused at *c*. 4 mm from the base, obtuse to broadly triangular, 5–5.3 mm × 5–5.5 mm, abaxial surface glabrous, adaxial surface pubescent except apices; apex of the free lobes revolute, glabrous at *c*. 3 mm from the tip (Figs. 9C–E & 15); corona staminal, 5–5.5 mm high, 5.5–6 mm diameter; coronal lobes ovate, *c*. 3.9 mm long, *c*. 2 mm diameter, inner process convex near the apex, raised above the outer process, centre of lobe convex, pinkish-red, outer process margin and upper skirt edge red, coronal lobe processes cream to yellowish, lower skirt edge translucent cream; coronal base adjoining skirt, and skirt extending out beyond it convex, coronal lobes with inflated skirt, attached to the base of the central column, forming a hollow below the corona, skirt under the corona slightly wider than the corona, fluted; stigma head almost white, *c*. 1.6 mm high, *c*. 1.7 mm diameter (Figs. 9I–N & 16–17); pollinarium *c*. 0.75 mm long, pollinia oblong, 0.57–0.58 mm × 0.16–0.18 mm, base tapering, apex obtusely angled, edges broad, flattened, pellucid edge clear, crest present, extending from the outer apex down to near the outer end, near the retinaculum, with a small bump along the outer edge, a quarter of the length from the base of the pollinium (see Fig. 9O); caudicles *c*. 0.11 mm × 0.05 mm; translators large, roughly triangular or scapula-shaped, *c*. 0.15 mm × 0.05 mm (Fig. 9O & 18). **Fruits** and **seeds** not seen.

ETYMOLOGY. The species is named after Ben Chai, who collected the Type material and who, at one time, had a large *Hoya* collection at his home in Sabah. His *Hoya* collection has since been dispersed and material established in other collections.

ECOLOGY. According to Ben Chai, this species came from the Telupid area, which is largely hill ultramafic forest at *c*. 500 m.

DISTRIBUTION AND CONSERVATION STATUS. Known only from one locality in the ultramafic forest in Sabah. The Forest Research Centre of the Sabah Forest Department, under the Sabah Red List project for plants, has assessed this species as Vulnerable (VU) under the IUCN Red List Categories, and as D2 under the criteria for that category as it is only known from one collection in a restricted area of ultramafic forest surrounded by several forest reserves. At present, we can only assume it is not threatened, as ultramafic soils are also not recommended for agriculture. However, these forests are at high risk from fires in drought years. Further collections will provide more information on its distribution. It has an AOO of 4 km^2. It has been propagated by Kipandi Park.

SPECIMENS EXAMINED—BORNEO. SABAH: Telupid, *Ben Chai* in Lamb *AL 2132/2011,* east of Ranau, 8th May 2011, from plant cultivated at Kipandi (holotype SAN; isotype SNP). A living plant was established in the Kipandi Park under accession no. H 37 with a spirit collection of 11 flowers collected in 2013 (*AL 2466/2013*, SAN).

NOTES. The original living collections of Ben Chai have been dispersed and established at Kipandi Park from which the type was made, and in Kota Kinabalu by Anthony Lamb. *Hoya benchaii* is closely related to *H. kloppenburgii* as both have similar revolute corolla

Fig. 10 (left). *Hoya benchaii*. General view of leaves and inflorescence. **Fig. 11** (right). *Hoya kloppenburgii*. General view of the plant and inflorescence. Photos: Anthony Lamb.

Fig. 12 (left). Close-up of *H. benchaii* flowers. **Fig. 13** (right). Close-up of *H. kloppenburgii* flowers. Photos: Anthony Lamb.

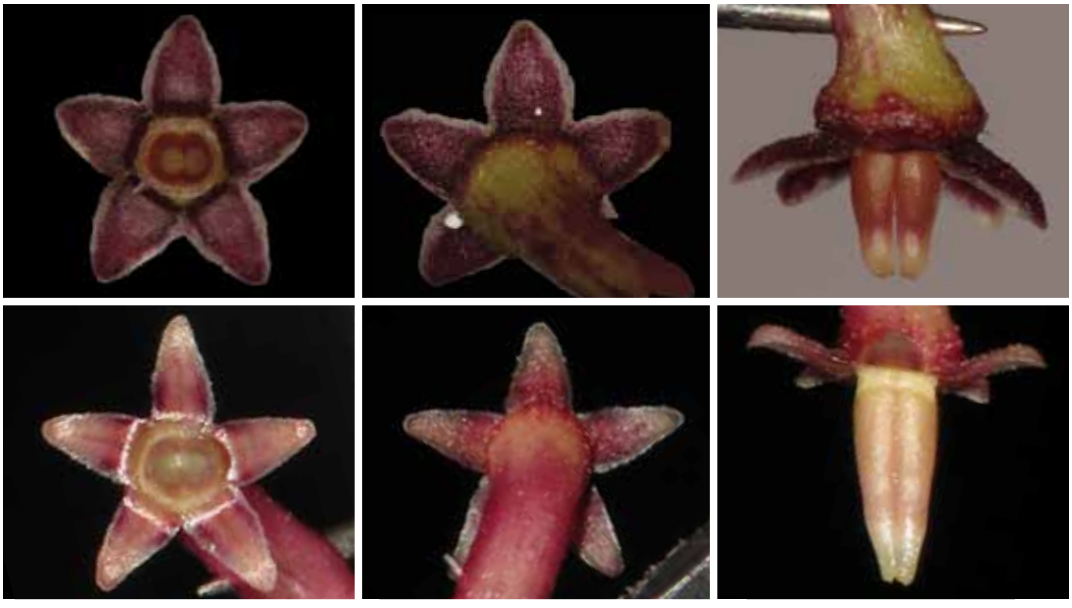


Fig. 14. Apices of pedicels, calyx lobes and bi-carpellate ovary. From left to right: adaxial view of calyx lobes and ovary; abaxial view of calyx and apex of pedicel; and thirdly, side-view of pedicel, calyx lobes and bi-carpellate ovary in *H. benchaii* (above) and *H. kloppenburgii* (below). Photos: A. Gavrus.

Fig. 15. Views of corolla and corona of *H. benchaii* (above), and *H. kloppenburgii* (below). From left to right; adaxial views; abaxial views showing revolute margins of corolla lobes; pedicel and calyx; and side views of pedicel, corolla and corona. Photos: A. Gavrus.

Fig. 16. Views of corona for *H. benchaii* (above) and *H. kloppenburgii* (below). From left to right: adaxial views; abaxial views and side views showing the unusual skirt below the corona lobes. Photos: A. Gavrus.

Fig. 17. *H. benchaii* (above) and *H. kloppenburgii* (below). (left) side views of corona with one lobe removed to show central column and stigma head with coronal lobes on each side with skirts; (right) corolla below corona. Photos: A. Gavrus.

Fig. 18. Pollinarium of *H. benchaii* (left) and *H. kloppenburgii* (right). Note the translator is yellowish and scapula-shaped, and the caudicle greyish in colour. Photos: A. Gavrus.

lobes, partly finely pubescent corolla on the adaxial surfaces, an unusual skirt under the corona lobes, masking the base of the column (filament tube), which is often visible in species without a skirt. This skirt is also found in other Sabah and Bornean Hoyas, such as *H. danumensis*, and *H. retrorsa*, together with another new taxon described in this paper, *H. sigillatis* ssp. *paitanensis*.

However, *H. benchaii* can be differentiated from *H. kloppenburgii* in having ovate leaves as compared to lanceolate leaves (Figs. 10 & 11). *H. kloppenburgii* also has a positively geotropic inflorescence with a long peduncle and an umbel of flowers that is flat to slightly concave; however, there are many more flowers per umbel, up to 15–20 (*AL 2463/2013*, SAN), as against 4–11 in *H. benchaii* (Figs. 12 & 13). The basal part of the corolla in *H. kloppenburgii* is cream to pale yellow with white pubescent hairs, but pink and glabrous under the corona (Figs. 13, 15 & 17) in *H. benchaii*. The bi-carpellate ovary in *H. kloppenburgii* is much more pointed, and longer, 2 mm compared to 1.6–1.8 mm in *H. benchaii* (Fig. 14).

The coronal lobes in *H. kloppenburgii* are wholly convex, and the skirt under the basal lobe forms a small ledge before becoming convex and is smaller than in *H. benchaii* (Figs. 16 &

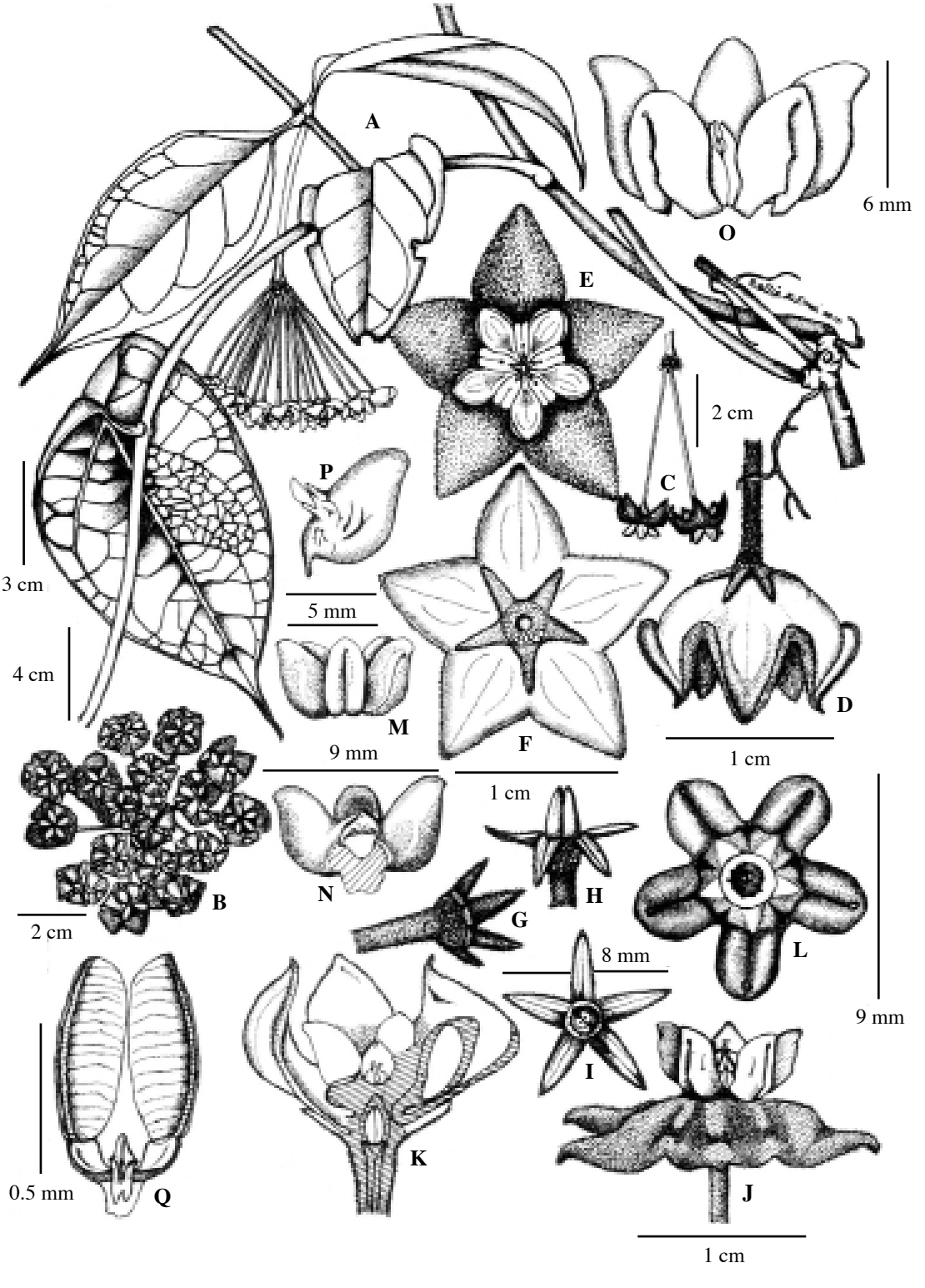
17). The whole lobe is cream to pale yellow, with only a thin pink edge, where the skirt joins the lobe, compared to the largely pinkish red lobes, with a cream apex to the inner process, and lower outer process in *H. benchaii* (Figs. 16 & 17).

The pollinia in *H. benchaii* are larger and narrower than in *H. kloppenburgii*, which have sharply angled upper edges to the pollinia, and no bump along the pellucid edges. Also, the caudicles of the pollinarium in *H. kloppenburgii* are smaller, and the translators are sickle-shaped or curved, with the head of the retinaculum larger and more rounded (see scales in Fig. 18). Specimens of *H. kloppenburgii* collected included *Linus Gokusing* in Lamb *AL 2025/2010*, Kipandi accession no. 14, Borneo, Malaysia, Sabah, from the river Paitan, on 11th October, 2010 in SAN.

2. Hoya chewiorum *A. Lamb, A. Gavrus, B. Emoi & L. Gokusing* **sp. nov.**

Hoya fraterna Bl. similes sed plantae folium parviorem 6–8 cm longa, 3–4 cm lata, floris corollae lobus pubescens (nec ciliatus) differt, calicys sepalum brevis, differt. Typus: Linus Gokusing & Jongir Lombika in Lamb AL 1769/2009, Borneo, Malaysia, Sabah, Central Crocker Range, c. 600–800 m altitude, Sg. Kopongian on the upper reaches of Moyog river, 30th April 2009, cultivated at Kipandi Park, accession no. H 40 (holotypus SAN; isotypus SNP). **(Figs. 19, 20, 22 & 24–28)**

Moderately robust climber, reaching up to 7 m high, glabrous; sap milky-white. **Stem** 8–10 mm thick, bark greyish, branching 0.5–2 m long, climbing; internodes 4–19 cm long, 3–5 mm thick, adventitious roots developing along internodes. **Leaves** opposite, variable; petiole green (when fresh), grooved, 1–2 cm long, 0.2–0.3 cm thick, glabrous; lamina elliptic, thin, 6–8 cm × 3–4 cm, adaxial surface dark green, glabrous, abaxial surface light green, base broadly tapering, apex acuminate, glabrous; veins prominent, pinnate veins impressed, secondary veins 45° to mid-vein, forming loops near the margins. **Inflorescence** positively geotropic, convex umbel of 15–30 flowers, with mildly sweet to pungent scent (Figs. 19A, 20 & 22); peduncle persistent, 4–10 cm long, *c.* 0.2 cm thick, rachis extending until 1–2.5 cm over three years producing a series of umbels. **Flowers:** pedicels green, 4.3–4.8 cm long, *c.* 0.1 cm thick, being all the same length in the umbel, pubescent; calyx pentamerous, *c.* 3 mm diameter, pubescent with small colleters; calyx lobes subulate, green, *c.* 3 mm × 1 mm, apex acute, adaxial surface pubescent, abaxial surface glabrous (Figs. 19D, G–I, 24); ovary bi-carpellate, obclavate, *c.* 2 mm high, *c.* 1.5 mm diameter, glabrous (Figs. 19H & 24); corolla campanulate; adaxial surface pubescent, abaxial surface glabrous (Figs. 22 & 25); corolla base bowl-shaped, 4 mm from the column to the base of the corolla lobes; corolla lobes acute to obtuse, spreading on opening, becoming reflexed upwards, with margins revolute (Figs. 19C–F, 22 & 25), turning from yellow to yellowish-orange, *c.* 7 mm × 7 mm, apex acute, adaxial surface yellow-orange, finely pubescent, abaxial surface waxy yellow, glabrous; corona staminal 9–10 mm diameter; coronal lobes ovate, waxy cream, *c.* 5 mm high, *c.* 2.5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mm diameter, inner process narrow, *c*. 1 mm long, outer process erect, *c*. 3 mm × 2.5 mm, higher than the inner process (Figs. 19E, J–P, 26 & 27); stigma head cream, *c*. 1.5 mm high, *c*. 2.5 mm diameter; pollinarium *c*. 0.87 mm long, pollinia oblong to elliptic, *c*. 0.75 mm × 0.25 mm, base tapering, apex flattened at an angle, pellucid edges clear, crest present; caudicles wedge-shaped, *c*. 0.15 mm × 0.07 mm; translators narrow, curved, *c*. 0.2 mm × 0.03 mm; retinaculum *c*. 0.23 mm long (Figs. 19Q & 28). **Fruit** and **seeds** not seen.

ETYMOLOGY. The species is named in honour of brothers Philip and Steven Chew, who set up the Kipandi Park with Linus Gokusing and supported the establishment of a living collection of the *Hoya* species that are found in Sabah.

ECOLOGY. This species is only known on trees from the banks of streams in the upper reaches of the Moyog River, on sandstone strata, at 600–800 m altitude in disturbed mixed hill dipterocarp forest. The few plants seen were climbing up trees to about 7 m high.

DISTRIBUTION AND CONSERVATION STATUS. Known only from the central Crocker Range in Sabah. Its present distribution is near to the Crocker Range National Park, where it might possibly occur also. It is likely to be threatened by shifting cultivation in its present habitat. Further collections are needed to provide a better picture of its distribution. The Sabah Forest Department's ongoing Red List project assessed its status as Vulnerable (VU) following the IUCN Red List Categories, and as D2 under the criteria for that category. It is also in cultivation at Kipandi Park.

SPECIMENS EXAMINED—BORNEO. SABAH: Penampang, Central Crocker Range, Sg. Kopongian, *Linus Gokusing* in Lamb *AL 1524/2008*, 7th October 2008 (holotype SAN,

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Fig. 19 (opposite). ***Hoya chewiorum***. Botanical drawing by Bellia Emoi, based on *Linus Gokusing* in Lamb *AL 1769/2009*, Borneo, Malaysia, Sabah, Central Crocker Range, 30th April 2009 in SAN and living material from accession no. H 40 at Kipandi Park, prior to material being pressed. **A.** Flowering branch with glabrous internodes, petioles and leaves with a positively geotropic peduncle and a convex umbel of flowers. **B.** An umbel of opened flowers seen from below. **C.** Apex of peduncle showing two flowers fully opened, with reflexed corolla lobes. **D.** Side view of flower during opening stage, showing hairy pedicel and calyx lobes; glabrous abaxial surface and hairy adaxial surface of corolla, with revolute corolla lobe margins. **E.** Top view of flattened corolla with pubescent corolla lobes and corona. **F.** Bottom view of flower with glabrous corolla and pubescent calyx lobes on the abaxial surface. **G.** Apex of pubescent pedicel and calyx lobes with small colleters. **H.** Side view of pedicel apex, calyx lobes, and glabrous bi-carpellate ovary. **I.** Top view of glabrous calyx lobes, and bi-carpellate ovary. **J.** Side view of opening flower showing corona lobes and pollinarium. **K.** Cross-section of flower showing positions of pedicel, calyx, bi-carpellate ovary, corolla and corona lobes (diagram not to scale). **L.** Bottom view of corona. **M.** Side view of corona. **N.** Cross-section of corona. **O.** Another side view of corona lobes, showing coronal grooves. **P.** Side view of corona lobe and attachment to anther. **Q.** Pollinium, showing pollinia with pellucid edges and crest (wings), with connecting caudicles (clear), narrow translators (stippled) and retinaculum.

isotype SNP), (a living plant was established at Kipandi Park under accession no. H 40); *Linus Gokusing* in Lamb *AL 1769/2009*, 30th April 2009, from the same cultivated plant; Sg. Kopongian, that joins Sg. Moyo, near Kipandi, *Lamb AL 2215/2011*, 19th October 2011 (SAN, SNP).

NOTES. The only collections were from a plant established at Kipandi. The first herbarium collection, *Linus Gokusing* in Lamb *AL 1524/2008*, Sabah, Central Crocker Range, collected by Linus Gokusing on 7/10/2008 in SAN, had cream flowers that had only just opened, and the corolla lobes had not become reflexed. Subsequent, specimens taken of *Linus Gokusing* in Lamb *AL 1769/2009*, on 30th April 2009 (the type specimen) from the same cultivated plant, had umbels of flowers, where the fully opened flowers had turned orange and the lobes of the corolla were reflexed. A further specimen from the original site, on the Sg. Kopongian that joins the Moyog river, near Kipandi, *Lamb AL 2215/2011*, had much longer internodes and leaves.

Fig. 20 (left). *Hoya chewiorum*. General view of leaves and inflorescence. **Fig. 21** (right). *Hoya fraterna*. General view of a plant in the Crocker Range showing leaves and positively geotropic inflorescence. Photos: Anthony Lamb.

Fig. 22 (left). Close-up of the inflorescence of *H. chewiorum*, showing the fine pubescence on the corolla. Photo: Steven Chew. **Fig. 23** (right). Close-up of *H. fraterna* flowers, showing the long silver hairs on the corolla lobes. Photo: Anthony Lamb.

Hoya chewiorum is closely related to *H. fraterna*, which is also found in Sabah in the Crocker Range, and some plants were discovered in the same area as *H. chewiorum*, but at higher elevations, and to *H. coriacea* Blume, which has not yet been found in this area or in Sabah. Other related species are *H. linusii* A. Lamb, A. Gavrus & B. Emoi described in this paper, and the little known *H. phyllura* O. Schwartz (1931).

Hoya fraterna is a very strong climber, climbing up into the riverine trees to over 10 m and in ridge forest. The lamina is larger, 18 cm × 7 cm with peduncles having 20–40 flowers per umbel (Wenstrom & Stenman 2008), and up to 60 flowers in umbels for plants found in the Crocker Range (Figs. 21 & 23). However, in *H. chewiorum* the lamina is smaller, to 6.8 cm × 3.4 cm with peduncles having 15–30 flowers per umbel. Both *H. fraterna* and *H. chewiorum* have reflexed corolla lobes. However, in *H. fraterna*, the corolla lobes are covered with very long, silvery hairs (Fig. 25), as against finely pubescent hairs in *H. chewiorum*. The corona lobes and pollinia are similar, but *H. fraterna* has stigma head which is covered with a "lace form" anther membrane, completely covering the pollinia, against a narrow membrane in *H. chewiorum*, where the pollinia are not always covered (Figs. 26 & 27). *H. linusii* has glabrous corolla lobes, which are never reflexed, and much more flattened corona lobes with acute outer lobe apices against more rounded ones in *H. chewiorum*.

Hoya fraterna specimens from the Crocker Range included *Lamb AL 2139/2011* and *AL 1724/2009* (SAN). Kipandi accession no. H 12.

Fig. 24. Apices of pedicels, calyx lobes with colleters and bi-carpellate ovaries. From left to right: adaxial views of calyx lobes and ovary; abaxial views of calyx lobes and apex of pedicel; side views of pedicels, calyx lobes, colleters and bi-carpellate ovaries of *H. chewiorum* (above) and *H. fraterna* (below). Photos: A. Gavrus.

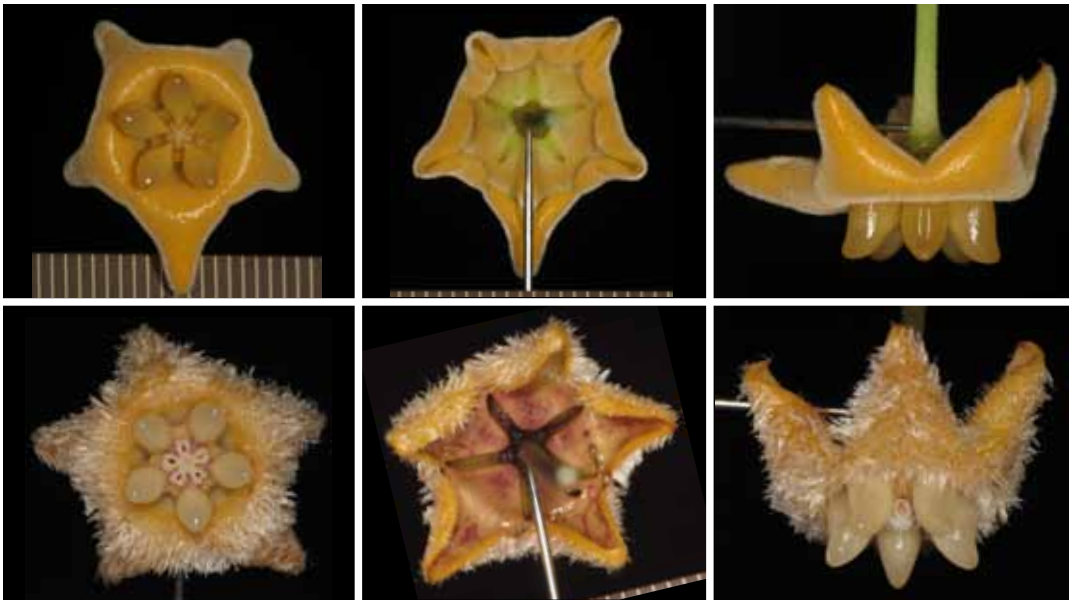

Fig. 25. Views of corolla and corona for *H. chewiorum* (above), and *H. fraterna* (below). From left to right: adaxial views showing cup-shaped base of corolla with corona and reflexed corolla lobes; abaxial view showing calyx and reflexed corolla lobes; side views of pedicel, corolla and corona. Photos: A. Gavrus.

Fig. 26. Views of corona in *H. chewiorum* (above) and *H. fraterna* (below). From left to right: adaxial views; abaxial views and side views. Photos: A. Gavrus.

Fig. 27. *H. chewiorum* (above) and *H. fraterna* (below). From left to right: side views of corona with one lobe removed to show the central column and stylar head with coronal lobes on either side; the corolla surface below the corona. Photos: A. Gavrus.

Fig. 28. Pollinium of *H. chewiorum* (left) and *H. fraterna* (right). Both have similar-shaped retinaculums, caudicles and translators, with a clear crest along the pellucid edge. Photos: A. Gavrus.

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3. Hoya hamiltoniorum *A. Lamb, A. Gavrus, B. Emoi & L. Gokusing* **sp. nov.**

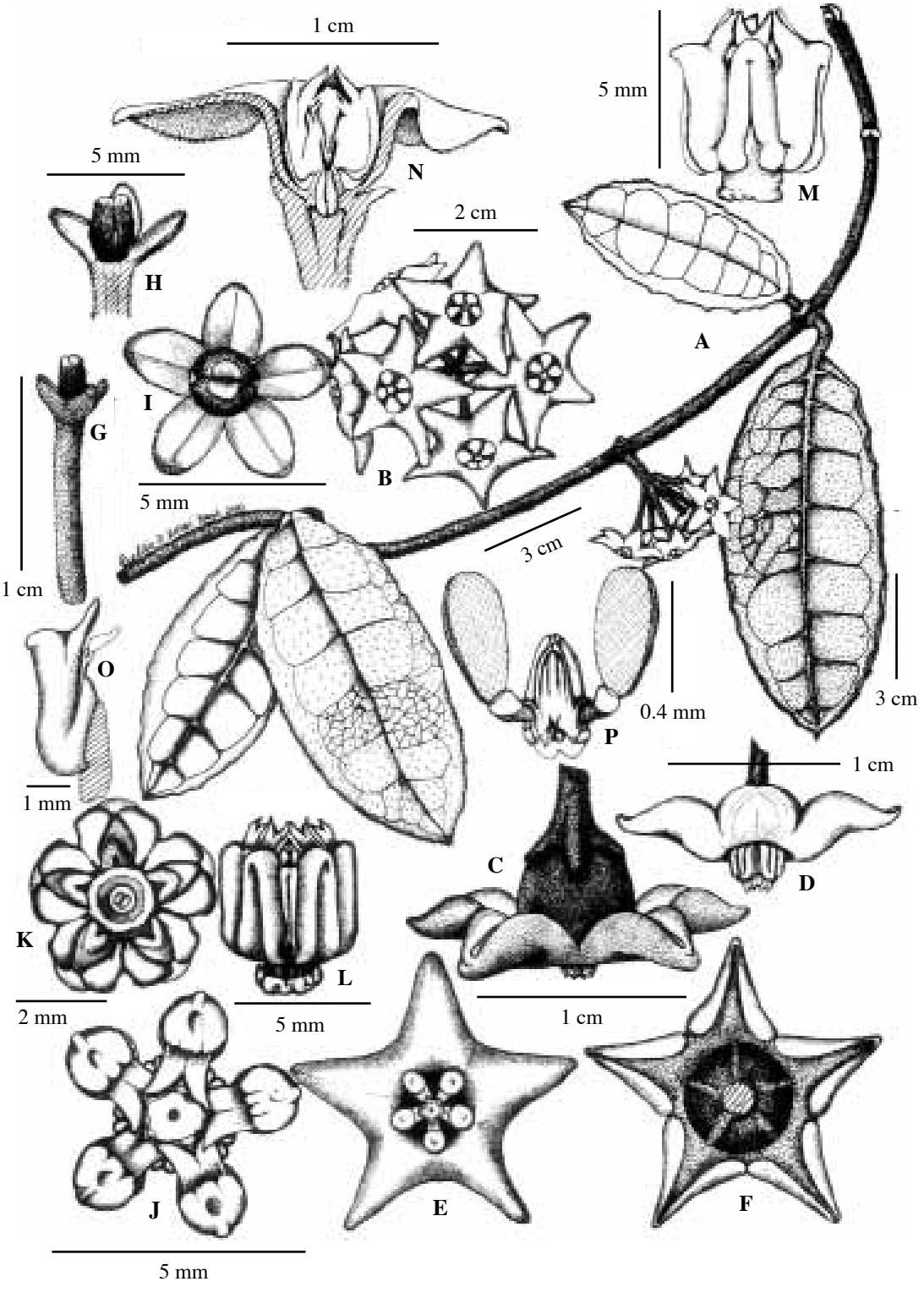
Hoya telosmoides Omlor similes sed floris ovario pubescens (nec glabro); floris corollae labus incrassatus et patens (nec gracilis semi-patens) floris coronae lobus bifidus horizontalis, generis singularis differt. Typus: Linus Gokusing & Jongir Lombika in Lamb AL 1814/2009, Borneo, Malaysia, Sabah, Ulu Tomani, c. 1200 m altitude, Tenom District, 26th August 2009, cultivated at Kipandi Park, accession no. H 39 (holotypus SAN; isotypus SNP). **(Figs. 29, 33, 38–41 & 44)**

Moderately robust epiphytic climber, 2–3 m high; sap milky-white in all parts. **Stem** terete, bark greyish-brown, branching to 2 m long, climbing; internodes 5–7 cm long on basal old stems, glabrous, branch internodes 5–21 cm long, green, pubescent, to 3 mm thick, a few adventitious roots developing along internodes. **Leaves** opposite; petiole terete, green, 1–1.5 cm long, 0.3–0.4 cm thick, pubescent; lamina elliptic to oblong, thin, stiff, 6–17.7 cm × 3–6 cm, adaxial surface dark green, sparsely pubescent, abaxial surface paler green, pubescent, base rounded, apex acute to acuminate; margin crenulate and turned downwards; pinnate-

veined, mid-vein impressed on adaxial surface, prominent on abaxial surface, secondary veins faintly visible, at right angles to the midvein. **Inflorescence** negatively geotropic, with convex to semi-globose umbel of 5–14 flowers, to *c*. 5 cm across, *c*. 2 cm in depth, with a strong sweet scent at night; peduncle lateral to erect, persistent, 1–2.5 cm long, 0.3–0.4 cm thick, pubescent; rachis producing a series of flowers, extending over 2–3 years to 1–2 cm (Figs. 33A–B & 29–32). **Flowers:** pedicels cream-coloured with pink spots, 1.2–1.6 cm long, *c*. 0.1 cm thick, pubescent; calyx pentamerous, pale green with purple spots, c. 5 mm diameter, covered in golden hairs; calyx lobes spotted purple, 1.6–3.0 mm × 1.3–1.5 mm, densely covered in golden hairs, apex rounded, hairy on adaxial surface, glabrous on abaxial surface; ovary bi-carpellate, obclavate, covered in cream to golden hairs, apex cream or pink to purple, glabrous (Figs. 33C, G–I & 38); corolla campanulate, cream to ivory-white, 1.7–2 cm diameter; corolla base cup-shaped, *c*. 6 mm diameter, *c*. 5 mm deep, containing the corona, adaxial surface cream, covered in silvery-white hairs, abaxial surface cream with

Figs. 29 & **30.** General view of plant stem (left) and globose inflorescences (right) of *H. hamiltoniorum*. Photos: J & G. Hamilton (left) and A. Lamb (right).

Figs. 31 & **32.** Close-up of inflorescence and flowers of *H. hamiltoniorum*, showing the unusual bifid inner processes of the corona above the cup-shaped base of the corolla. Photos: J & G. Hamilton.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scattered purple spots, densely pubescent; corolla lobes triangular, 7–7.5 mm × 6–7 mm, adaxial surface waxy cream, glabrous, abaxial surface cream with scattered purple spots, densely pubescent (Figs. 33C, F, N & 39); corona staminal seated in the cup-shaped base of the corolla, 4.5–5 mm high, *c*. 4 mm diameter, centre of the coronal lobe cream; coronal lobes erect, 4.5–5 mm high, *c*. 2 mm diameter, inner process bifid, pale pink, 1–5 mm above the cup-shaped corolla base, *c*. 1.0 mm × 0.5 mm at the base, the outer process cream, with the coronal groove clearly visible, *c*. 4.5 mm × 1.5 mm (Figs. 33D–E, J–O & 40–41); stigma head white, 2.5–3 mm high, *c*. 0.5 mm diameter (Figs. 29N & 41); pollinarium *c*. 0.6 mm long, pollinia oblong, *c*. 0.5 mm × 0.1 mm, base rounded, apex rounded, pellucid edge clear, crest present; caudicles *c*. 0.5 mm × 0.2 mm; translators roughly triangular, *c*. 0.2 mm × 0.05 mm (Figs. 33P & 43). **Fruits** and **seeds** not seen (but since the ovary was covered in golden hairs, the fruits would probably also be covered in golden hairs) (Fig. 44).

ETYMOLOGY. The species is named after John and Gina Hamilton, who have lived in Kota Kinabalu, Sabah, for the past 12 years. They have a keen interest in *Hoya* species, maintaining a living collection, and who have accompanied one of the authors (Anthony Lamb), on many field trips.

ECOLOGY. The species occurs in upland mixed dipterocarp forest to lower montane forest from 600–1200 m. Of the three collections made in Sabah, the type is from lower montane forest on sedimentary sandstone soils, and the second collection which is very close, but needs further study, is from the slopes of Mount Magdalena on the Merotai Kanan river in

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Fig. 33 (opposite). ***Hoya hamiltoniorum***. Botanical drawings by Bellia Emoi based on *Linus Gokusing* in Lamb *AL 1814/2009*, and living type plant material prior to pressing (cultivated at Kipandi Park, accession no. H 39). **A.** Flowering branch, the younger internodes and petioles pubescent, the leaf margins crenulate and finely revolute, the abaxial of younger leaves being more densely hairy than the adaxial surface. Note the inflorescence depicted is, in fact, laterally held at a more upright angle (and is negatively geotropic). **B.** Inflorescence of open flowers. **C.** Flower showing apex of the densely pubescent pedicel and calyx lobes, the outer surface of the campanulate corolla base is pubescent, and the corolla lobes with revolute margins. **D.** Side view showing the top of the corona lobes, seated in the campanulate cup- shaped base of the corolla. **E.** Adaxial surface of the corolla lobes and corona glabrous, but with hairs in the tubular base. **F.** Abaxial surface of the corolla covered in hairs except for the revolute margins of the lobes. **G.** Pubescent pedicel and calyx showing the unusual hairy bi-carpellate ovaries, which are glabrous at the apices. **H.** Close-up of the hairy bi-carpellate ovaries. **I.** Adaxial surface of the calyx lobes, which are glabrous, as are the apices of the ovary. **J.** Top view of the corona showing the unusual bifid inner (apical) processes. **K.** Bottom view of the corona. **L.** Side view of the corona showing the bifid inner processes, coronal grooves of the outer processes and groove between the anther wings. The column base of the stamens with fused filaments is also shown. **M.** Side view of corona from a different angle. **N.** Cross-section of the corona sitting in the campanulate corolla cup-shaped base, showing the position of the ovaries and calyx. **O.** Detail of a coronal lobe joined to the back of the anther, showing the anther appendage. **P.** Pollinarium with pollinia showing the very thin crest and pellucid edges, caudicles (clear), and translators (stippled) joined to the retinaculum.

Figs. 34 & **35.** General view of plant stem (left) and inflorescences (right) of *H. telosmoides* for comparison. Photos: Anthony Lamb.

Figs. 36 & **37.** Close-ups of the inflorescences and flowers of *H. telosmoides*, showing the urn-shaped corolla (left) and the corona hidden by white hairs at the base of the corolla lobes (right). Photos: Anthony Lamb

Tawau Hills Park, in hill forest on weathered volcanic soils. The third is from hill forest on sandstone soils at 650 m in the Central Crocker Range.

DISTRIBUTION AND CONSERVATION STATUS. Known only from Sabah, in the Crocker Range, and possibly Tawau Hills Park.

This species has been assessed as Least Concern (LC), following the IUCN Red List Categories, as it has a wide distribution. Further collections would provide a better distribution pattern; however, one specimen, *H*. aff. *hamiltoniorum* came from within a totally protected State Park, another within a commercial Forest Reserve adjacent to the Crocker Range, and the third is from unallocated Stateland in the Central Crocker Range adjacent to the Crocker Range National Park. Hence, it does not appear to be threatened at present. It is also in cultivation at Kipandi Park.

SPECIMENS EXAMINED—BORNEO. SABAH: Tenom, Ulu Tomani at 1200 m, *Linus Gokusing* in Lamb *AL 1814/2009*, 26th August 2009 (holotype SAN; isotype SNP) (a living plant was established at Kipandi Park under accession no. H 39); Tawau Hills Park, *Dolois Sumbin et al. SP16224*, October 2011 (SNP); Central Crocker Range at *c*. 650 m, *Linus Gokusing et al*. in Lamb *AL 2214/2011*, October 2011 (SAN).

NOTES. *Hoya hamiltoniorum* which was found as an epiphytic climber in compost in the forks of trees, 1200 m in lower montane forest, at Ulu Tomani, and terrestrial on river banks in hill forest in the Central Crocker Range, has no really closely comparable species due to the unusual flowers with a bifid inner process on the corona, and a corolla with a cup-shaped base. The nearest species we might compare it to, which has such a base, is *H. telosmoides* Omlor (1996), which also occurs in the Crocker Range. The corona with fairly large bifid inner processes, and a hairy bi-carpellate ovary and hairy follicles have not been seen in other Borneo species so far. However in *H. obtusifoliodes*, which has a minutely pubescent bi-carpellate ovary (which looks glabrous), develops a follicle, the surface of which is covered in clearly discernable pubescent hairs. *Hoya albiflora* Zipp. *ex* Blume, from New Guinea, has, according to Kloppenburg (pers. comm.), a minutely pubescent ovary, but not like the long golden-brown hairs seen on *H. hamiltoniorum*.

Another *Hoya* species with very similar flowers was brought to my attention by Pia Nutt (pers. comm.), in Germany, who submitted a Diploma thesis on A Checklist of *Hoya* of Borneo (Nutt 2001), with a drawing of the flowers of a Sarawak collection made by Haviland (*Haviland* 8530, Borneo, Malaysia, Sarawak). But as can be seen from her drawing, the similar 'cup'-shaped flower has a totally different laterally held corona (Fig. 42). This has since been described as *H. nuttiana* Rodda & Simonsson (2013).

Hoya telosmoides is another montane species found at similar altitudes, with a cup- or urn-shaped base to the corolla, but this totally encloses the corona which is not visible.

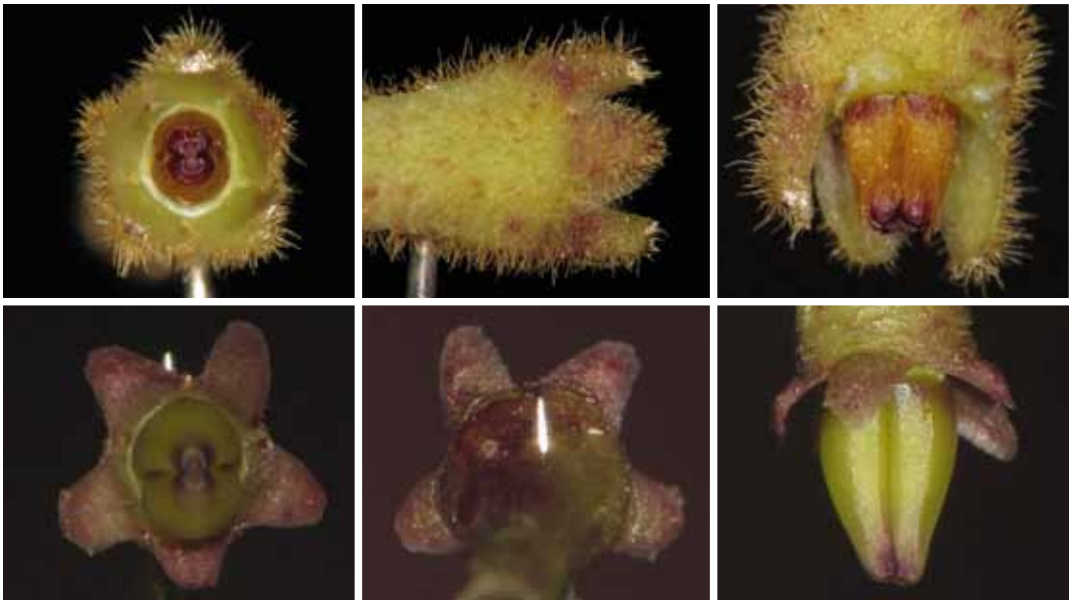


Fig. 38. Apices of pedicels, calyx, colleters and bi-carpellate ovary. From left to right: adaxial views of calyx lobes and ovary; abaxial views of calyx and apex of pedicel; side-views of pedicel, calyx, colleters, and bi-carpellate ovary of *H. hamiltoniorum* (above) and *H. telosmoides* (below). Photos: A. Gavrus.

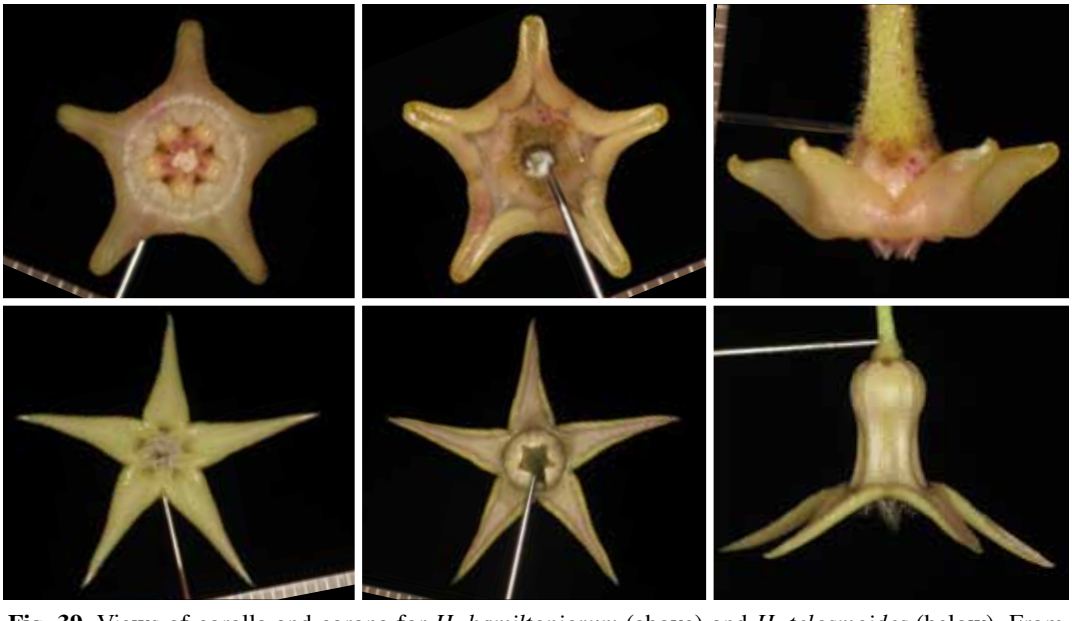


Fig. 39. Views of corolla and corona for *H. hamiltoniorum* (above) and *H. telosmoides* (below). From left to right: adaxial views showing cup-shaped base of corolla with corona visible for *H. hamiltoniorum*, but hidden by hairs for *H. telosmoides*; abaxial views showing revolute margins of corolla lobes and the calyx lobes; side views of pedicel, calyx lobes and corolla, showing the cup and urn-shaped base of the corolla. Photos: A. Gavrus.

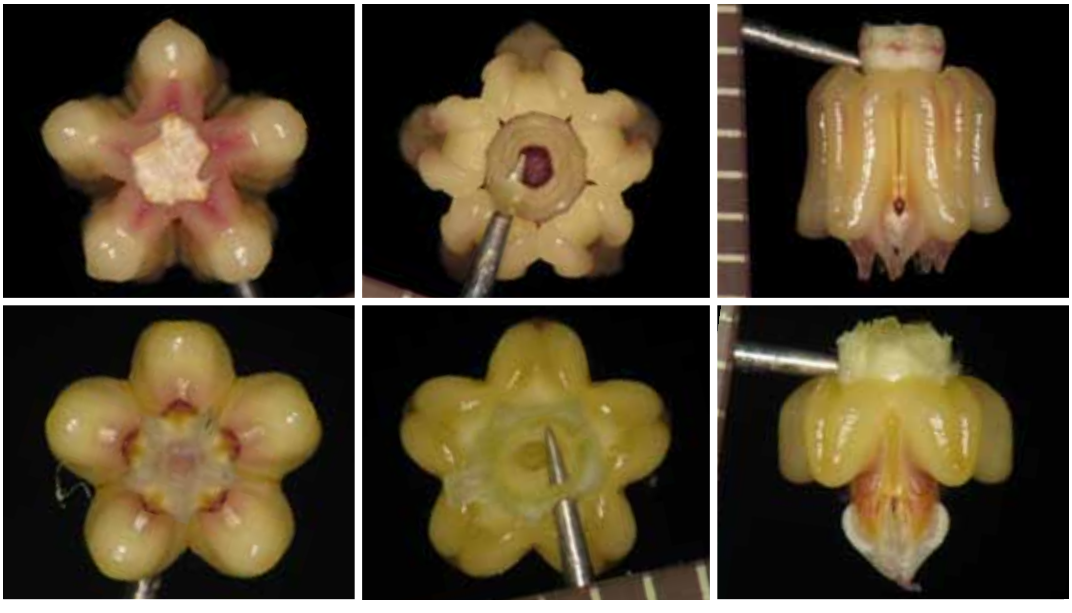


Fig. 40. Views of the corona of *H. hamiltoniorum* (above) and *H. telosmoides* (below). From left to right: adaxial views; abaxial views and side views. Photos: A. Gavrus.

Fig. 41. Dissected side view of corona, with and without the cup-shaped corolla of *H. hamiltoniorum* (above left and centre); and the urn-shaped corolla of *H. telosmoides* (below left and right), showing hairy sides of corolla, bi-carpellate ovaries and stigma head, with coronal lobes on either side, and the corolla base below the corona for *H. hamiltoniorum* (above right). Photos: A. Gavrus.

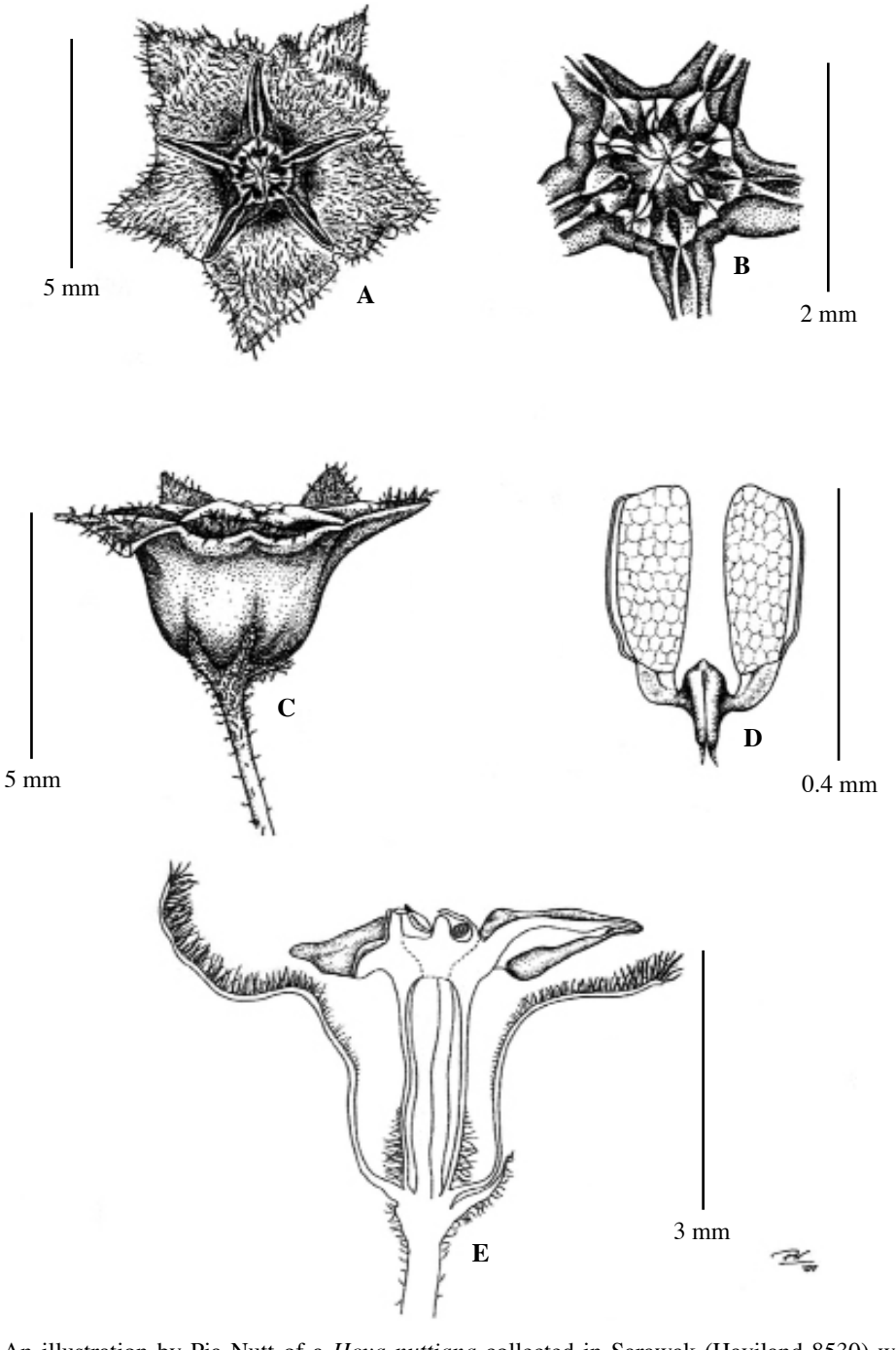


Fig. 42. An illustration by Pia Nutt of a *Hoya nuttiana* collected in Sarawak (Haviland 8530) with a similar cup-shaped flower. However, the laterally held corona lobes and hairy adaxial surface of the corolla lobes are different to *H. hamiltoniorum*.

Fig. 43 (above). Pollinarium of *H. hamiltoniorum* (left) and *H. telosmoides* (right). Both have similar shaped retinaculums, but pollinia of a narrower pellucid edge for *H. hamiltoniorum*. Photos: A. Gavrus. **Fig. 44** (left). The immature hairy follicles of a *Hoya* sp. aff. *H. hamiltoniorum* photographed on a specimen from Tawau Hills Park (SP 1622 in SNP). Photo: Anthony Lamb.

The inflorescences, however, have up to 30 flowers (specimens seen by Anthony Lamb in the Crocker Range) and the outer abaxial surfaces of the flowers are glabrous, as are the leaves (Figs. 34–37), whereas the leaf surfaces and the abaxial surface of the corolla in *H. hamiltoniorum* are pubescent (Fig. 33A, C & F). However, both species have flowers with a strong sweet scent.

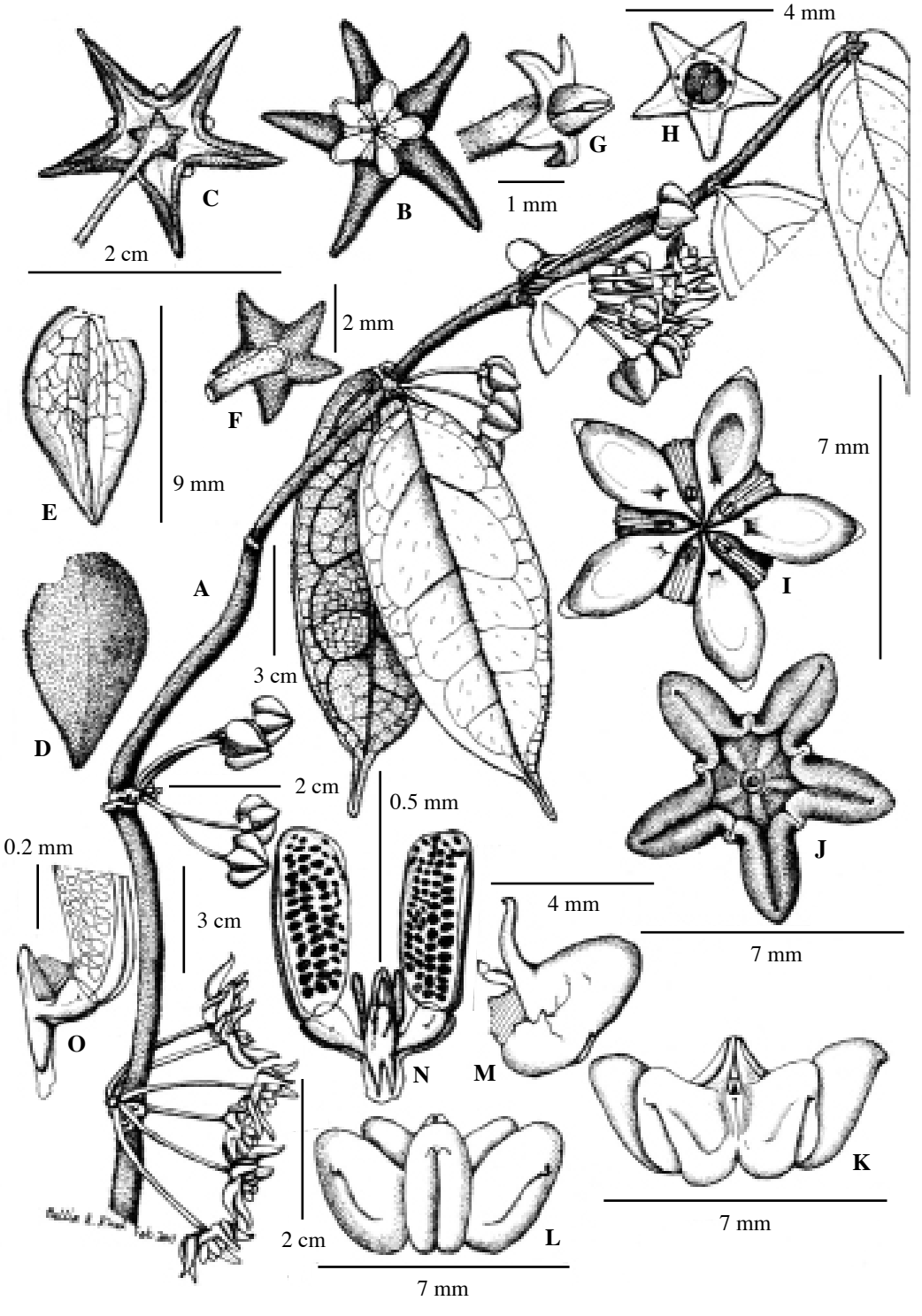
Two immature follicles, 2.3 cm × 6 mm, covered in golden brown hairs (Fig. 44) were seen on a specimen (*SP 16224*), collected in Tawau Hills Park, which appeared to be very close to *H. hamiltoniorum* based on very similar leaves and flowers with the unusual bifid inner process of the corona, indicating that *H. hamiltoniorum* with a hairy bi-carpellate ovary would have similarly hairy fruits. However, more research is needed as the specimen had distinctly different outer processes and longer peduncles, according to M. Rodda (pers. comm.). *Hoya telosmoides* has a glabrous, long thin seed pod.

4. Hoya kipandiensis *A. Gavrus, A. Lamb, B. Emoi & L. Gokusing* **sp. nov.**

Hoya burmanica Rolfe similes sed plantae folium lanceolatum pubescens 7–14 cm longum, 3.5–6 cm latus (nec folio 5–9 cm longa, 1.5–2.5 cm lata); flores pedunculatus 0.2 cm longum (nec 1 cm longum), differt. Typus: Linus Gokusing in Lamb AL 1909/2010, Borneo, Malaysia, Sabah, central Crocker Range, c. 600 m altitude, Mongkusilad River, near Kg. Kipandi, 25th January 2010, cultivated at Kipandi Park, accession no. H 44 (holotypus SAN; isotypus SNP). **(Figs. 45, 46, 48 & 50–56)**

Moderately robust terrestrial climber to *c.* 7 m high, pubescent; sap milky-white in all parts. **Stem** terete, base 15–30 cm long, *c.* 10 mm thick, glabrous, bark grey-brown, basal internodes *c.* 6 cm long, nodes enlarged, adventitious roots developing along internodes, branching and climbing up to *c.* 7 m high. Leafy branching stems terete, green, pubescent; internodes 4–10 cm long, 3–4 mm thick, scattered adventitious roots occurring along internodes. **Leaves** opposite; petiole grooved, green (younger stems), becoming grey with age, 0.5–0.6 cm long, 0.3–0.4 cm thick, pubescent; lamina elliptic, thin, 7–14 cm × 3.5–6 cm, adaxial surface dark green, young leaves having scattered hairs that fall off later, abaxial surface light green, densely pubescent; base rounded, apex long acuminate, margin with ciliate hairs; pinnate-veined, mid-vein on adaxial surface slightly depressed, secondary veins visible at 70° angle to midvein for the whole length of the midvein, forming loops near the margins, mid-vein and secondary veins on abaxial surface prominent, pubescent (Fig. 45A

Fig. 45 (opposite). ***Hoya kipandiensis***. Botanical drawing by Bellia Emoi, based on *Linus Gokusing* in Lamb *AL 1909/2010* and living type material prior to specimens being pressed, cultivated at Kipandi Park, accession no. H 44. **A.** Flowering branch with finely hairy stem internodes and very short petioles, elliptic leaves, with acuminate leaf apices. The leaves are densely hairy on the abaxial surface, with scattered hairs on the adaxial surface. The inflorescences occur at many nodes at the same time, with extremely short peduncles, alternating from upper and lower surfaces of the nodes. **B.** Upper surface of a flower showing the minutely pubescent adaxial surface of the corolla. The lobes are only fused near to the base, with strongly revolute margins, producing a star-shaped flower. **C.** The glabrous abaxial surface of the corolla showing the revolute margins of lobes with pubescent adaxial surface. **D.** Corolla lobe flattened showing the ovate shape with minutely pubescent adaxial surface. **E.** Flattened corolla lobe showing the glabrous abaxial surface. **F.** The apex of the pedicel with scattered hairs, while the adaxial surface of the calyx and calyx lobes pubescent. **G.** The apex of the pedicel, calyx and calyx lobes with a distinctly beak-shaped, glabrous, pointed bi-carpellate ovary. **H.** Calyx lobes and bi-carpellate ovary from above, showing glabrous abaxial surface of the lobes. **I.** The corona from above, showing the very narrow inner processes. **J.** The corona from below showing the coronal grooves. **K.** Side view of the corona lobes showing the erect thinly pointed inner processes. **L.** Side view of the outer processes with the revolute edges, forming the coronal grooves with a small hook-shaped apex. **M.** Side view of a single corona lobe showing the distinct erect narrow inner process and attachment to the anther. **N.** Pollinia showing broad pellucid edges with a crest, joined to the retinaculum by the caudicles (clear) and translators (stippled), with wings joined to the retinaculum at the shoulders. **O.** Showing the wing from the side attached to the shoulder of the retinaculum, above the translator and caudicle joined to the base of the pollinia.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7 mm

& 46). **Inflorescence** positively geotropic, convex umbel of 4–8 flowers, 3.5–5.0 cm across, strongly sweet-scented, with a hint of aniseed; peduncle persistent, very short, to *c*. 0.2 cm long, 0.1–0.2 cm thick, glabrous, alternate on upper and lower surfaces of nodes; rachis producing a series of flowers, extending up to 0.2–0.3 cm over 2–3 years (Figs. 45A, 46 & 48). **Flowers**: pedicels pale green to cream with pink spots, 1.5–1.7 cm long, *c*. 0.1 cm thick, glabrous to slightly pubescent; calyx pentamerous, to *c*. 2 mm diameter with few hairs; calyx lobes triangular, white with some pink spots, *c*. 1 mm × 0.8 mm, pubescent on abaxial surface, glabrous on adaxial surface; ovary bi-carpellate, beak-shaped, greenish-cream, apex acute, *c*. 1.5 mm high, *c*. 0.8 mm diameter at base, glabrous (Figs. 45A, C, F–H & 50); corolla star-shaped, cream, 1.6–1.7 cm diameter, 7–8 mm in depth; corolla lobes spreading, fused at 4 mm from the base, ovate, *c*. 7 mm × 2 mm (with margin revolute), *c*. 7 mm × 4.5 mm (with lobes flattened out), abaxial surface glabrous, adaxial surface minutely pubescent (Figs. 45A–E, 48, 51 & 53); corona staminal 3–3.5 mm high, 6–7 mm diameter; coronal lobes ovate from above, creamy-yellow, *c*. 3 mm high, *c*. 1.5 mm diameter, centre of lobe rounded, inner process long pointed, to 1.5 mm long, raised just above the outer process, outer process top with small hooked apex above the coronal groove (Figs. 47B, I–M, 48 & 51–53); stigma head cream, *c*. 2 mm high, *c*. 1.2 mm diameter (Fig. 53); pollinarium *c*. 0.7

Fig. 46 (left). *Hoya kipandiensis*. General view of stem, pinnately-veined leaves and inflorescences with very short peduncles on the type plant. Photo: Steven Chew. **Fig. 47** (right). *Hoya burmannica* Rolfe. General view of cultivated plant with an inflorescence. Photo: A. Gavrus.

mm long, pollinia obovate, *c*. 0.46 mm × 0.17 mm, base tapering, apex rounded, pellucid edge clear, crest present; caudicles scapula-shaped, *c*. 0.13 mm × 0.1 mm; translator linear, *c*. 0.16 mm × 0.05 mm, retinaculum *c*. 0.3 mm × 0.7 mm with two wings joined to the retinaculum at the shoulder, from the front view of the pollinarium the wings are seen as the front linear edge, *c*. 0.12 mm long, from the side view the wings are translucent, more or less triangular, *c*. 0.12 mm × 0.1 mm × 0.7 mm (Figs. 45N, O & 54–55). **Fruit** a follicle, the pod dark green with some darker patches, linear, 9–10 cm × 0.5–0.6 cm (Fig. 56). **Seeds** not seen.

Fig. 48 (left). Close-up of inflorescence showing star-shaped flowers of *H. kipandiensis*, with free, narrow and revolute-edged corolla lobes. Photo: Steven Chew. **Fig. 49** (right). Close-up of inflorescence and flowers of *H. burmanica* with similar short peduncle, free lobes to the base of the corolla, with partly revolute margins of lobes. Photo: A. Gavrus.

ETYMOLOGY. The species is named after the locality in which it was first discovered, near the village of Kipandi, in the valley of Mongkusilad River in the Central Crocker Range, near to the Crocker Range National Park in Sabah.

ECOLOGY. This species is a climber found on river banks in hill dipterocarp forest at 200–600 m on alluvial deposits, on both sandstone and volcanic soils. The plant in Tawau Hills Park was reported to be climbing up a juvenile dipterocarp, *Shorea johorensis* Foxw.

DISTRIBUTION AND CONSERVATION STATUS. Known only from Sabah, in the Central Crocker Range, also in the Tawau Hills Park. Another plant of this species was observed in the Sapulot area in Nabawan District by Linus Gokusing, but no collection was made at the time. With more collecting efforts, a wider distribution could be expected. The first locality is close to the Crocker Range National Park, and the second within the Tawau Hills

Fig. 50. Apices of pedicels, calyx and bi-carpellate ovary. From left to right: adaxial views of calyx lobes and ovary; abaxial views of hairy calyx, calyx lobes and apex of pedicel; side-views of pedicel, calyx and bi-carpellate ovaries of *H. kipandiensis* (above) and *H. burmanica* (below). Photos: A. Gavrus.

Fig. 51. Views of corolla and corona of *H. kipandiensis* (above) and *H. burmanica* (below). From left to right: adaxial views showing corona and corolla lobes with both species having minutely pubescent surface and revolute margins of corolla lobes, but differently shaped corona lobes; abaxial views showing apex of pedicel, calyx lobes and glabrous surface of corolla lobes with more revolute margins in *H. kipandiensis*; side views of pedicels, corolla and corona. Photos: A. Gavrus.

Fig. 52. Views of corona in *H. kipandiensis* (above) and *H. burmanica* (below). From left to right: adaxial views, abaxial views and side views to show coronal grooves, position of pollinium and base of column. Photos: A. Gavrus.

Fig. 53. *H. kipandiensis* (above) and *H. burmanica* (below). (left) side views of corona with one lobe removed to show the central column, stigma head with coronal lobes on either side; (right) the corolla surface below the corona. Photos: A. Gavrus.

Figs. 54 & **55.** Pollinarium (above) and retinaculum wings (below) of *H. kipandiensis* (left) and *H. burmanica* (right); both have similarly shaped pollinia and wings on the retinaculum. Photo: A. Gavrus.

Park, which are in totally protected areas, and so this species could be assumed not to be threatened. The Sabah Forestry Department has assessed it as Least Concern (LC) due to its wide distribution and presence in a Protected Area. The species has an AOO of 12 km^2.

SPECIMENS EXAMINED—BORNEO. SABAH: Penampang, Mongkusilad River, *Linus Gokusing* in Lamb *AL 1909/2010* on 25th January 2010 (holotype SAN, isotype SNP) (a living plant was established in the Kipandi Park under accession no. H 44, and observed over a three-year period); Tawau Hills Park, trail leading to the Gelas waterfall at 200–300 m, *G. Geofarry et al. SP 15019*, 24th February 2000 (SNP).

Fig. 56. An immature follicle of *H. kipandiensis* with the pinnate veining on the abaxial surface of the lamina clearly seen. Photo: Steven Chew.

NOTES. *Hoya kipandiensis* appears to have no closely related species in Sabah or Borneo so far as is known. In terms of foliage, it is similar to another new montane epiphytic species, *H. hamiltoniorum*, in the shape of the leaves, and the fact that both have leaves that are sparsely hairy on the adaxial surface, and densely pubescent on the abaxial surface. Both have internodes on the younger branches, with adventitious roots and petioles that are also pubescent. But in the case of *H. hamiltoniorum*, the leaf margins are turned down and crenulate (Figs. 29 & 33A) which does not happen in *H. kipandiensis*. However, the inflorescences and the flowers of these two species are very different (Figs. 30, 31–33 & 45), with *H. kipandiensis* having a positively geotropic umbel of star-shaped flowers, and free lobes to near the base of the corolla, whereas *H. hamiltoniorum* has a negatively geotropic globose umbel of campanulate flowers with a cup-shaped base. Particularly unique features of *H. kipandiensis* are the wings on the retinaculum of the pollinarium (Figs. 45N, O & 54–55). Another species found in Myanmar in which wings are recorded on the retinaculum is *H. burmanica* (Figs. 54–55). It also has long free pubescent corolla lobes, with revolute margins, but the corona differs, and the leaves are lanceolate and not elliptic (Figs. 47 & 49). *Hoya kipandiensis* flowers are very strongly sweet-scented, and with its creamy white flowers, it probably attracts moths as pollinators, but this has not yet been observed.

5. Hoya linusii *A. Lamb, A. Gavrus & B. Emoi* **sp. nov.**

Hoya chewiana A. Lamb, A. Gavrus, B. Emoi & L. Gokusing similis sed plantae folium base angusta cuneata (nec cordata); floris corollae lobus patens glaber (nec reflexus pubescens) differt. Typus: Linus Gokusing in Lamb AL 1223/2007, Borneo, Malaysia, Sabah, upper reaches of the Moyog river in the Central Crocker Range, c. 500 m altitude, Penampang District, 13th November 2007, cultivated at Kipandi Park, accession no. H 24 (*holotypus* SAN; *isotypus* SNP). **(Figs. 57, 60–63 & 66–71)**

Moderately robust terrestrial climber to 10 m high, glabrous; sap milky-white in all parts. **Stem** basal part with bark corky grey-brown, lower internodes to *c*. 10 cm long, *c*. 8 mm diameter, branching, younger branches green, internodes 7–15 cm long, 2–5 mm diameter, glabrous. **Leaves** opposite; petiole curved, grooved, green, 1–2 cm long, 0.2–0.5 cm thick; lamina elliptic, thin, 9–13 cm × 4–6.5 cm, adaxial surface green, glabrous, abaxial surface light green, glabrous; base rounded, apex acuminate, 1–1.5 cm long; pinnate-veined, midvein on adaxial surface impressed, secondary veins clearly visible and branching from the mid-vein at an acute angle of 45º along most of the midvein, forming loops near the margins, mid-vein and secondary veins on abaxial surface prominent, glabrous (Figs. 57A & 60–61). **Inflorescence** positively geotropic, convex umbel of 10–28 flowers (average 15–20), faintly fragrant; peduncle pendulous, persistent, green, 1–3 cm long, 0.3–0.4 cm thick, glabrous; rachis producing a series of flowers extending (0.5)1.5–2 cm long, 0.4–0.5 cm thick over three years (Figs. 57A–B, 60–63). **Flowers:** pedicels green, 2.5–4 cm long, *c*. 0.1 cm thick, glabrous; calyx pentamerous, 2.5–3 mm diameter with colleters, greenish-yellow; calyx lobes apex obtuse, creamy-yellow with translucent white edges, *c*. 1.5 mm × 1.5 mm, glabrous on both surfaces; ovary bi-carpellate, conical to skittle-shaped, base purple, apex cream, *c*. 2.2 mm high, *c*. 1.5 mm diameter, glabrous (Figs. 57E–H & 66); corolla saucer or

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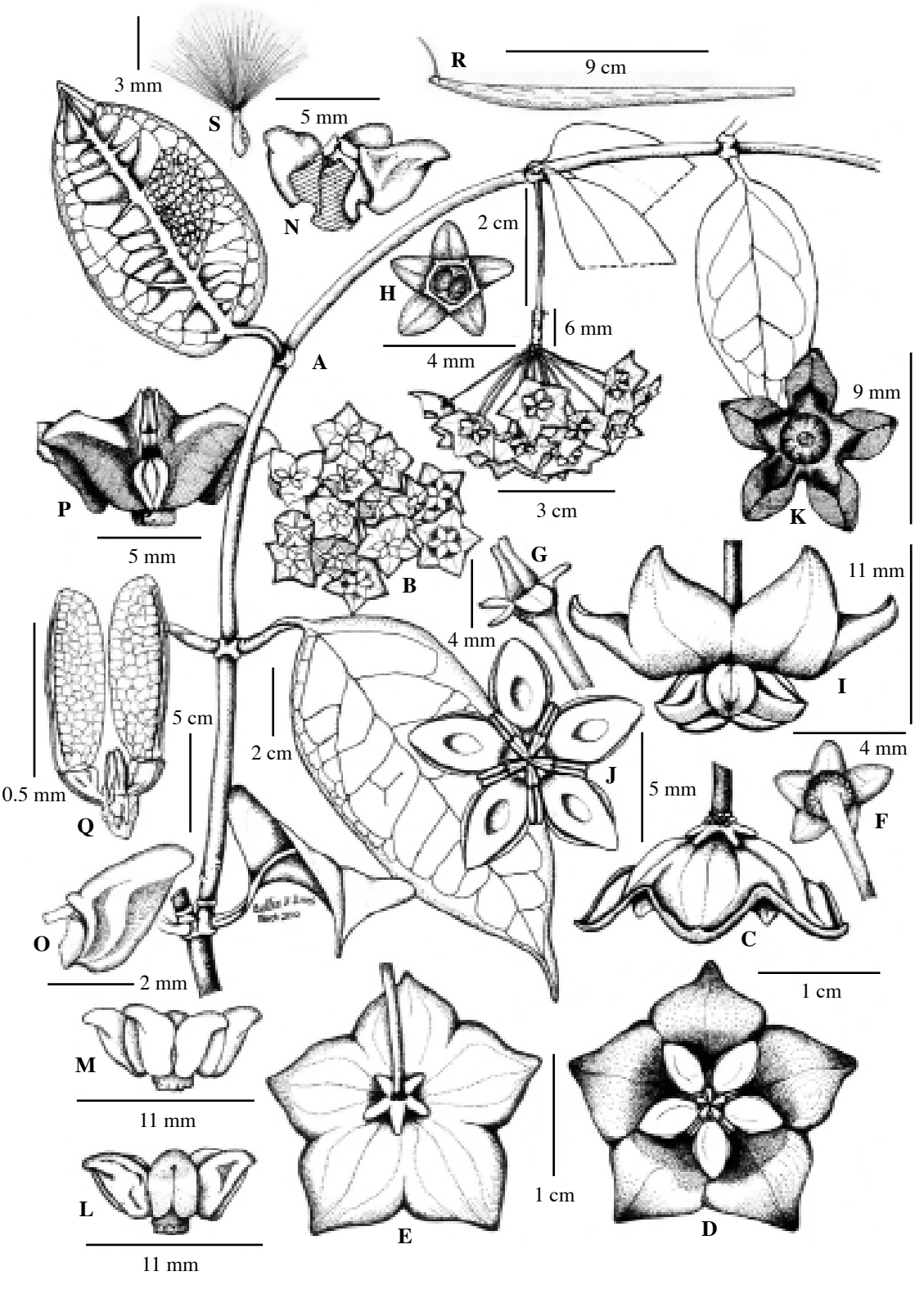
Fig. 57 (opposite). ***Hoya linusii***. Botanical drawing by Bellia Emoi, based on *Linus Gokusing* in Lamb *AL 1223/2007*, and living type material prior to pressing (cultivated at Kipandi Park), accession no. H 24. **A.** Flowering branch with glabrous stems, petioles and leaves. **B.** Inflorescence from below with some flowers just opening. **C.** Side view of saucer-shaped flower which is fully open, showing the apex of the pedicel with calyx and colleters. **D.** View from above of the corolla and corona, with glabrous corolla lobes. **E.** Flower from the back showing pedicel, calyx and glabrous abaxial surface of the corolla. **F.** The pedicel and calyx with colleters and glabrous abaxial surface of calyx lobes. **G.** Side view of pedicel, calyx lobes and long, conical to skittle-shaped, glabrous, bi-carpellate ovary. **H.** View of calyx lobes from above showing the glabrous lobes and bi-carpellate ovary. **I.** Side view of flower, with corolla lobes forced up to show the corona. **J.** View of the corona from above, showing position of the pollinia and anther wings. **K.** View of corona from below. **L. & M.** Side views of the coronal lobes with the basal part of the column (filament tube). **N.** Cross-section of the corona showing the stigma head. **O.** Detail of corona lobe showing the inner and outer processes; and attachment to the back of the stamen. **P.** Side view of the corona, showing the pollinia and anther wings. **Q.** The pollinarium, pollinia with pellucid edges and crest, retinaculum, caudicles (clear) and translators (stippled). **R.** Follicle (seed pod). **S.** Seed with comma.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Figs. 58 & **59.** *Hoya chewiorum* (left) and *H. gildingii* (right), two species closest to *H. linusii*. Whereas *H. chewiorum* is found in similar hill forest habitat, *H. gildingii*, though closer morphologically, is found at 1500 m in lower montane forest. Photos: Anthony Lamb.

bowl-shaped, yellow to pale orange, 1.8–2.2 cm diameter (*c*. 2.6 cm when flattened), abaxial surface cream to yellow, glabrous, adaxial surface waxy, yellow to bright orange; corolla base saucer-shaped, 6–8 mm diameter, *c*. 3 mm deep; corolla lobes fused at 6–8 mm from base, apex obtuse to apiculate, *c*. 7 mm (along free edge) × 9 mm, some small white hairs along edges of lobes near the apex (Figs. 57C–E, & 60–63 & 67); corona staminal 3–4 mm high, 10–11 mm diameter; coronal lobes ovate, 5.5–5.7 mm high, 2.7–3 mm diameter in the centre, and *c*. 3 mm high for the outer basal process, inner process apex acuminate, waxy yellow, *c*. 1 mm long, glabrous (Figs. 57D, I–P, 62–63 & 67–69); stigma head cream to orange, *c*. 4 mm high, *c*. 2 mm diameter; pollinarium *c*. 1 mm long, pollinia elliptic, *c*. 0.73 mm × 0.22 mm, base rounded, apex narrowly flattened, pellucid edge clear, crest present; caudicles scapula-shaped, 0.14–0.16 mm × *c*. 0.09 mm; translator curved, linear, *c*. 0.22 mm × 0.015 mm diameter; retinaculum *c*. 0.23 mm × 0.13 mm, linear with no distinct shoulders (Figs. 57Q & 70). **Fruits** mature follicles yellowish, with white streaks, *c*. 18.5 cm × 0.7 cm (Fig. 71). **Seeds** not seen.

ETYMOLOGY. The species is named after Linus Gokusing, Manager of the Native Plant Gardens at Kipandi Park, who discovered and collected this species, and several other new species established at the Park.

ECOLOGY. According to Linus Gokusing, this species is a vigorous climber in vegetation along river banks at 400–600 m in hill dipterocarp forest on sandstone soils in the Central Crocker Range in Sabah, near to the Crocker Range National Park. The vegetation was dense and the *Hoya* was climbing up to 10 m high. In cultivation, this species produces inflorescences throughout the year.

Figs. 60 & **61.** *Hoya linusii*. (above) General view of leaves and inflorescence of the type plant at Kipandi Park (Photo: Steven Chew), and (below) terminal inflorescence (Photo: Anthony Lamb).

DISTRIBUTION AND CONSERVATION STATUS. Known only from Sabah, and occurring along two rivers in disturbed hill dipterocarp forest at 300–400 m altitude in the Central Crocker Range near Kipandi. The type, *Linus Gokusing* in Lamb *AL 1223/2007*, was collected in the upper reaches of the Moyog river. He later found more plants nearer to Kipandi, along the Mongkusilad River (see *Linus Gokusing* in Lamb *AL 2162/2011*). At present, as it has not been found in a protected area, so it could be threatened by shifting cultivation of the hill slopes in the area.

The Sabah Forest Department has assessed this species as Vulnerable (VU), based on criteria D2 due to its restricted distribution based on only two collections, the fact that it has not been recorded from any protected area, and may be threatened by shifting cultivation. However,

Fig. 62 (left). Close-up of flowers on an inflorescence of *H. linusii*, showing the saucer-shaped glabrous corollas and more laterally held corona lobes. **Fig. 63** (right). The abaxial view of an inflorescence showing the shape of the corolla and the slightly revolute margins of the lobes. Photos: Anthony Lamb.

Fig. 64 (left). Close-up of flowers on inflorescences of *H. chewiorum* with a finely pubescent corolla, and reflexed lobes. Photo: Steven Chew. **Fig. 65** (right). Compared to the more glabrous, white and pink, saucer-shaped corolla and purple corona of *H. gildingii* from Mount Kinabalu. Photo: Jamirus Jumian.

Fig. 66. Apices of pedicels, calyx, colleters, and bi-carpellate ovary. From left to right: adaxial views of calyx lobes and ovary; abaxial view of pedicel, calyx and calyx lobes (note the calyx lobes of *H. linusii* are more triangular compared to the longer acuminate calyx lobes of *H. chewiorum*); side-views of pedicels, calyx, colleters and bi-carpellate ovary of *H. linusii* (above), and *H. chewiorum* (below). Photos: A. Gavrus.

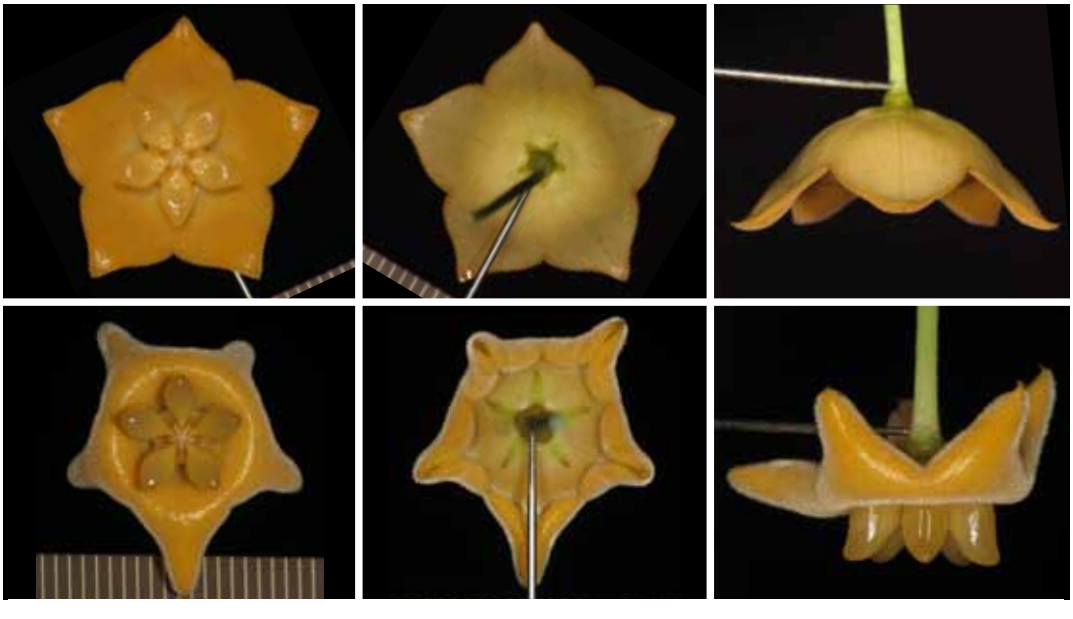

Fig. 67. Views of corolla and corona for *H. linusii* (above) and *H. chewiorum* (below). From left to right: adaxial views showing saucer-shaped corolla with spreading glabrous lobes and corona of *H. linusii*, compared to the pubescent corolla with reflexed lobes, of *H. chewiorum*; abaxial views of *H. linusii*, showing calyx and apex of pedicel on a saucer-shaped base, with triangular sepals and spreading glabrous corolla, with apices of lobes upturned. Compare this to the reflexed corolla lobes with strongly revolute edges and side views of pedicel, with longer acuminate calyx lobes, corolla and corona showing the more erect coronal lobes seated in a cup-shaped corolla base for *H. chewiorum*. Photos: A. Gavrus.

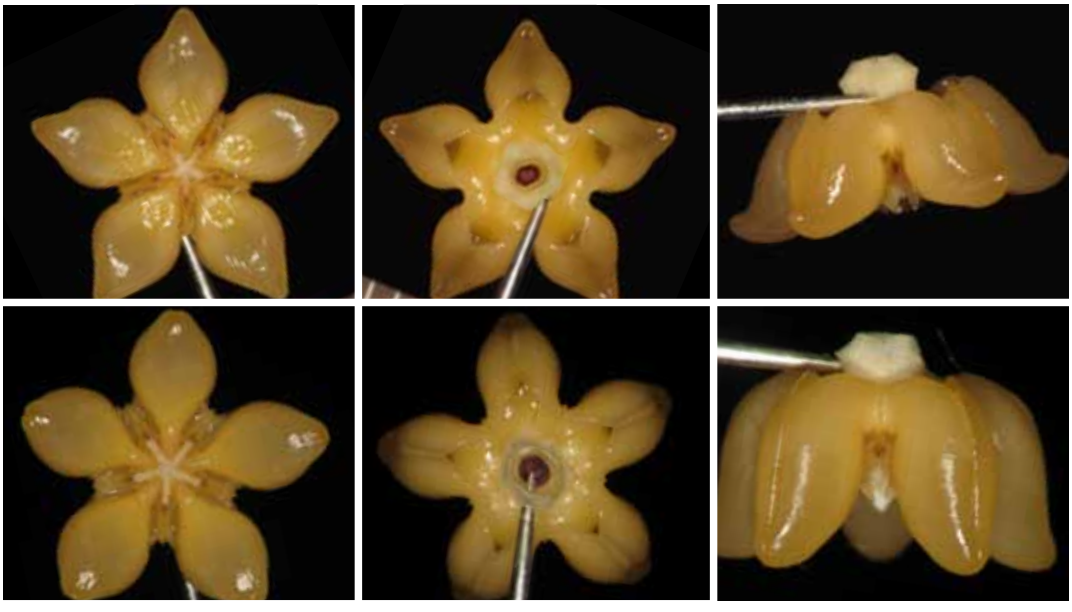

Fig. 68. Views of the corona of *H. linusii* (above) and *H. chewiorum* (below). From left to right: adaxial views; abaxial views and side views, showing similar-shaped lobes but with the lobes of *H. linusii*, on a more lateral plane compared to the more erect lobes of *H. chewiorum*. Photos: A. Gavrus.

Fig. 69. (left) *H. linusii* (above) and *H. chewiorum* (below). (left) side view of corona with one lobe removed to show the central column and stylar head with coronal lobes on either side; (right) the corolla surface below the corona. Photos: A. Gavrus.

Fig. 70. Pollinarium of *H. linusii* (left) and *H. chewiorum* (right), showing similar narrow translators, but with more distinct shoulders on the retinaculum of *H. chewiorum* . Photos: A. Gavrus.

more collections are needed to assess it further to see if it falls in a protected forest area, even though it has been cultivated and propagated at Kipandi Park. The species AOO is 8 km^2.

SPECIMENS EXAMINED—BORNEO. SABAH: Penampang, Sg. Moyog, *Linus Gokusing & Jongir Lombika* in Lamb *AL 1223/2007*, 13th November 2007 (holotype SAN, isotype SNP) (a living plant was established at Kipandi Park under accession no. H 24); Sg. Mongkusilad, in a valley below Kipandi Park, *Linus Gokusing* in Lamb *AL 2162/2011*, 15th July 2011.

NOTES. *Hoya linusii* is closely related to *H. chewiorum* A. Lamb, A. Gavrus, B. Emoi & L. Gokusing as both species are climbers, the leaves are elliptic and they both have similar venation type, and the flowers are yellow in colour. However, *H. linusii* has a glabrous adaxial corolla surface with the free lobes spreading, whereas *H. chewiorum,* the adaxial corolla surface is pubescent and the free lobes reflexed (Fig. 64). Also the corona lobes in *H. linusii* lie in a more horizontal plane (Figs. 62–63 & 68) whereas in *H. chewiorum*, the corona lobes

are erect (Fig. 68). Similar to *H. chewiorum* are *H. fraterna* Bl. and *H. coriacea* Bl., both having reflexed and pubescent corolla lobes.

Another comparable species brought to our attention by M. Rodda, who saw living material of *H. linusii* at Kipandi is *H. phyllura* O.Schwartz. A specimen, SAN 557884, collected in Borneo, Malaysia, Sarawak by Othman, Rantai, Jugah, Jefrey & Johnny, and determined by M. Rodda as *H. phyllura*, had no alcohol material, and we could not place it in *H. phyllura* with any certainty, when compared to the type material for *H. phyllura*. Materials in other herbaria have not been checked. We have had to refer to the type material collected by H. Winkler (no. 339, collection dated 24th November 1924) and for which there is no drawing of the pollinarium. The type specimen in the herbarium of Hamburg Botanic Gardens (HBG) provides measurements for only one peduncle, but the main differences we found were that for *H. phyllura*, the corollas were described as white in colour, 1.5–2 cm in diameter, with a white to yellowish corona, whereas for *H. linusii* flowers have yellow to orange corolla, 2.2–2.6 cm in diameter and cream to pale yellow corona. For *H. phyllura* the calyx lobes are shorter and narrower, *c*. 1 mm × 0.5 mm, compared to *H. linusii* with calyx lobes *c*. 1.7 mm × 1.6 mm (Fig. 66). We feel more material of *H. phyllura* is needed for study to further clarify the differences.

Fig. 71. Mature follicles of *H. linusii* on a plant in cultivation at Kipandi. Photo: Steven Chew.

Another Sabah species that occurs in lower montane forest at 1600 m altitude, *H. gildingii* Kloppenburg (2002), has a similarly shaped inflorescence with a convex umbel of flowers with spreading glabrous corolla lobes and a corona with ovate, laterally spreading coronal lobes (*AL 2017/2010*, Borneo, Malaysia, Sabah, Mount Kinabalu Park HQ area, 1500 m, 7th October 2010, collected by Anthony Lamb in SNP & SAN) as *H. linusii*. However, the flowers are pink to cream with purple on the corona, and it has much smaller leaves (Figs. 59 & 65) in *H. gildingii* whereas in *H. linusii*, the flowers are yellow to orange and the leaves are much larger and it is restricted to hill forest.

6. Hoya retrorsa *A. Gavrus, A. Lamb, B. Emoi & L. Gokusing* **sp. nov.**

Hoya spartioides (Benth.) Kloppenb. *similis sed folia acicularis 6–9 cm longa, 0.2 cm lata (nec efolia); inflorescentia flores solitarius (nec 3–8 flores); floris pedunculus 7–12 cm longa (nec 15–27 cm longa); floris pedicellaris recurvus distinctus, floris coronae lobus gracilis (nec incrassatus) differt. Typus: Linus Gokusing in Lamb AL 1950/2010, Borneo, Malaysia, Sabah, Pensiangan, Mount Lumatan, 1200 m altitude, 4th May 2010, cultivated at Kipandi Park, accession no. H 46 (holotypus SAN; isotypus SNP).* **(Figs. 72, 73, 76, 77 & 80–85)**

Epiphytic herb, with several basal branches, to 50 cm long, glabrous; sap milky-white in all parts. **Stem:** seedling plant starts with one main stem (Fig. 72) which then producing up to 10 main basal stems to *c*. 50 cm long (Fig. 73), glabrous, bark grey-brown; 1–2 branches per stem, to *c*. 0.28 m long; internodes 1.5–2.7 cm long, 2–2.5 mm diameter, adventitious roots absent along the stems. **Leaves** opposite, variable; petiole sessile; lamina (initial seedling leaves) green, elliptic, *c*. 4 cm × 0.8 cm, base rounded, apex acute, subsequent leaves becoming narrower and more linear, *c*. 4.5 cm × 0.35 cm, green, some becoming reddish in the sun, 6–9 cm × *c*. 0.2 cm, terete, shallowly sulcate, glabrous, base rounded, apex acute (Figs. 72A–B, 73, 76 & 77). **Inflorescence** negatively geotropic, single-flowered; peduncles produced alternately at the nodes, on the upper or lower surface, terete, green, erect or pendulous, persistent, always longer than the leaves, 7–12 cm long, 0.2–0.25 cm thick; rachis greyish-brown, 0.1–0.2 cm long, 0.2 cm thick, producing a single flower at a time. **Flowers:** pedicels cream, tinged green and pink, straight becoming recurved when flower matures, 1.2–1.5 cm long, *c*. 0.1 cm thick, glabrous; calyx pentamerous, *c*. 1.5 mm diameter, glabrous; calyx lobes deltoid, *c*. 0.5 mm × 0.3 mm, glabrous on both surfaces, pink with margin translucent white; ovary bi-carpellate, bottle-shaped, 2–5 mm high, *c*. 1.4 mm diameter at base, glabrous (Figs. 72A, C & D–F, I–K & 80); corolla 1.2–1.5 cm diameter, adaxial surface pubescent, abaxial surface glabrous; corolla lobes fused at 1 mm at the base, spreading, 5.5–7 mm × 2.3–3 mm, adaxial surface cream, tinged pink covered in white hairs, abaxial surface pink to red, glabrous, margins curved upwards (Figs. 72D–H & 82); corona staminal *c*. 4 mm high, *c*. 2 mm diameter; coronal lobes *c*. 4 mm high, *c*. 2 mm diameter at base of outer process, inner process *c*. 1 mm long, apex cream to white, base red, outer process greenish white (up to junction with inner process where it becomes red), *c*. 3 mm × 0.9–1 mm (Figs. 72D, L–O, 81 & 83); stigma head orange, *c*. 2 mm high, *c*. 1 mm diameter (Figs. 72P & 83); pollinarium 0.45 mm long, pollinia rectangular, *c*. 0.25 mm × 0.16 mm, base flattened, apex slightly flattened, pellucid edge clear in basal half, crest present; caudicles scapula-shaped, *c*. 0.06 mm × 0.04 mm; translators linear, curved, 0.1 mm × 0.01–0.02 mm; retinaculum obovate, *c*. 0.2 mm × 0.08 mm (Figs. 72Q & 84). **Fruit** a follicle, younger follicle pale green with some purple flecks, spindle-shaped, *c*. 8.5 cm × 0.25 cm (at widest point) (Figs. 72R & 85). **Seeds** not examined.

ETYMOLOGY. The species is named after the pedicel that curves down, and then recurves upwards after the flower opens. This feature of a re-curving pedicel is not seen in any other *Hoya* species in Sabah.

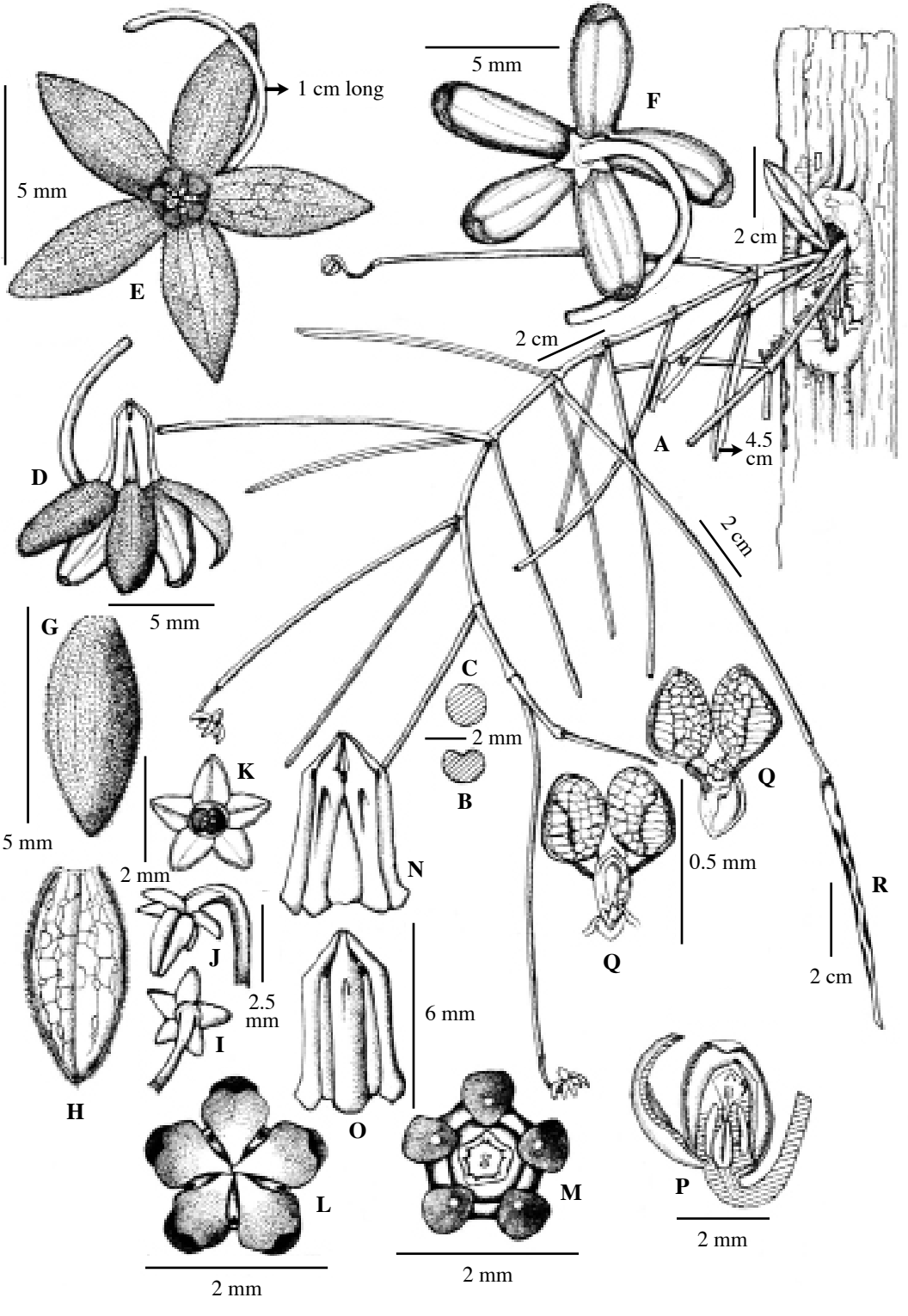
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Fig. 72 (opposite). ***Hoya retrorsa***. Botanical drawing by Bellia Emoi, based on *Linus Gokusing* in Lamb *AL 1950/2010* and living type material grown at Kipandi Park, accession no. H 46, prior to pressing the specimen. **A.** Flowering plant. The stem emerges from a hole in a branch or tree trunk. The first initial leaves are flat and elliptic, and then, they become narrower, until the stem has extended out from the host tree, when the leaves become sulcate terete. The terete peduncles are longer than the leaves and arise from the nodes alternately on the upper and lower surfaces of the nodes between the leaves. Single flowers only are produced from each peduncle. **B.** Cross-section of sulcate terete leaf. **C.** Cross-section of terete peduncle. **D.** Flower in the usual position after it opens with the pedicel curving so that the corona is pointing upwards. **E.** Flower showing the long corolla lobes which are only fused close to the base. The adaxial surface is minutely pubescent; the abaxial surface of the lobes are glabrous. **F.** Flower from the abaxial side, showing the curved pedicel and calyx, the glabrous abaxial surface of the corolla lobes with the margins upturned. **G. & H.** Adaxial and abaxial surfaces of the corolla lobes, which are minutely hairy and glabrous respectively. **I.** Apex of pedicel and glabrous calyx lobes from below. **J.** Side view of pedicel, calyx and bi-carpellate ovary. **K.** Calyx lobes and ovaries from above. **L.** Corona from above. **M.** Corona from below. **N. & O.** Side view of corona lobes. **P.** Cross-section of flower, showing pedicel, corolla and corona, the bi-carpellate ovary and stigma head. **Q.** Two pollinia showing retinaculum, caudicles (clear), translators (stippled) and pellucid edge of pollinia with crest. **R.** Follicle; as in many Hoyas, in Sabah, only one ovary seems to get fertilised and develops, the other aborts.

Fig. 73. General view of a plant showing 10 main stems with branches of *H. retrorsa*. Photo: Anthony Lamb.

Figs. 74 & **75.** General view of plants of *H. spartioides,* showing basal leaves and stems with only green peduncles and an inflorescence of several orange flowers (inset photo). Photo: Anthony Lamb.

Figs. 76 & **77.** Young plants of *H. retrorsa* (left) showing intitial linear leaves and plant with sessile terete leaves and large, green peduncles with a single flower (right). Photos: Anthony Lamb.

Figs. 78 & **79.** Close-ups of the inflorescences of *H. spartioides*. Photos: Anthony Lamb (left) and A. Gavrus (right).

ECOLOGY. This species was collected in lower montane forest between 1200 m and 1600 m altitude, on sandstone formations. It is associated with ants that appear to carry seeds into holes of branches or tree-trunks of under-storey trees, where rotting has occurred.

DISTRIBUTION AND CONSERVATION STATUS. So far, it is known only from Sabah, from two localities in the south. The first plant was collected by Linus Gokusing and Jongir Lombika in Ulu Tomani, Tenom District at 1200–1300 m altitude, as a seedling, still with its basal leaves, in April 2007 and established at Kipandi Park, where specimens of the flowers and leaves were taken in April 2008 (*Linus Gokusing* in Lamb *AL 1341/2008*, accession no. H 2). However, this plant died in August 2009. Linus Gokusing then found a mature plant on the slopes of Mount Lumatan, near Pensiangan, between 1300–1600 m, together with three immature plants. A specimen was taken from the mature plant (*Linus Gokusing* in Lamb *AL*

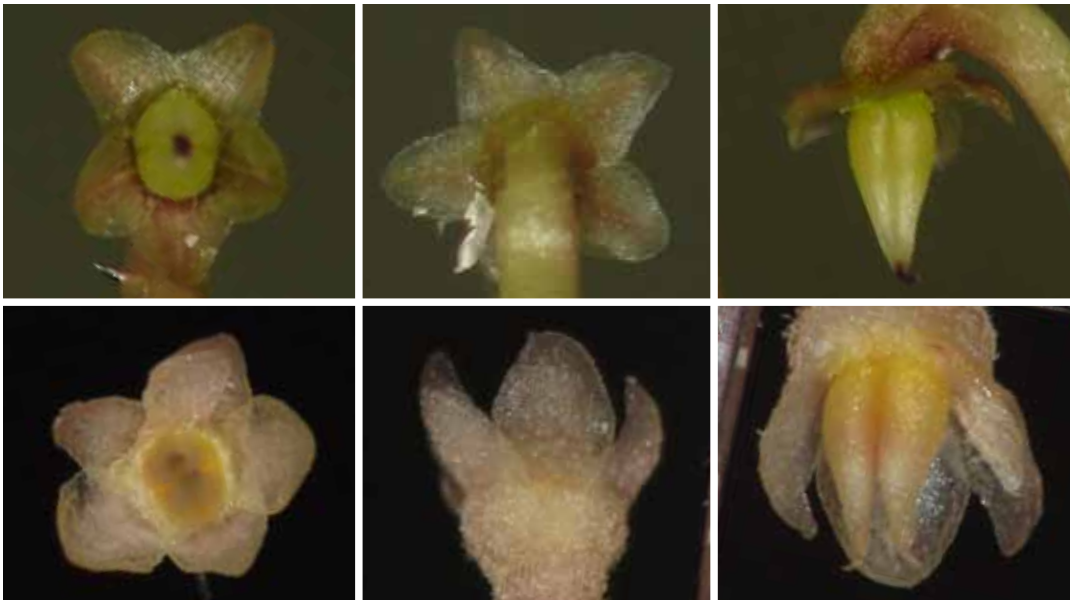


Fig. 80. Apices of pedicels, calyx lobes and bi-carpellate ovary of *H. retrorsa* (above) and *H. spartioides* (below). From left to right: adaxial view of calyx lobes and ovary; abaxial view of pedicel apex that are long, curved, and glabrous in *H. retrorsa* and short and hairy in *H. spartioides*, and side-view of pedicels, calyx and bi-carpellate ovaries . Photos: A. Gavrus.

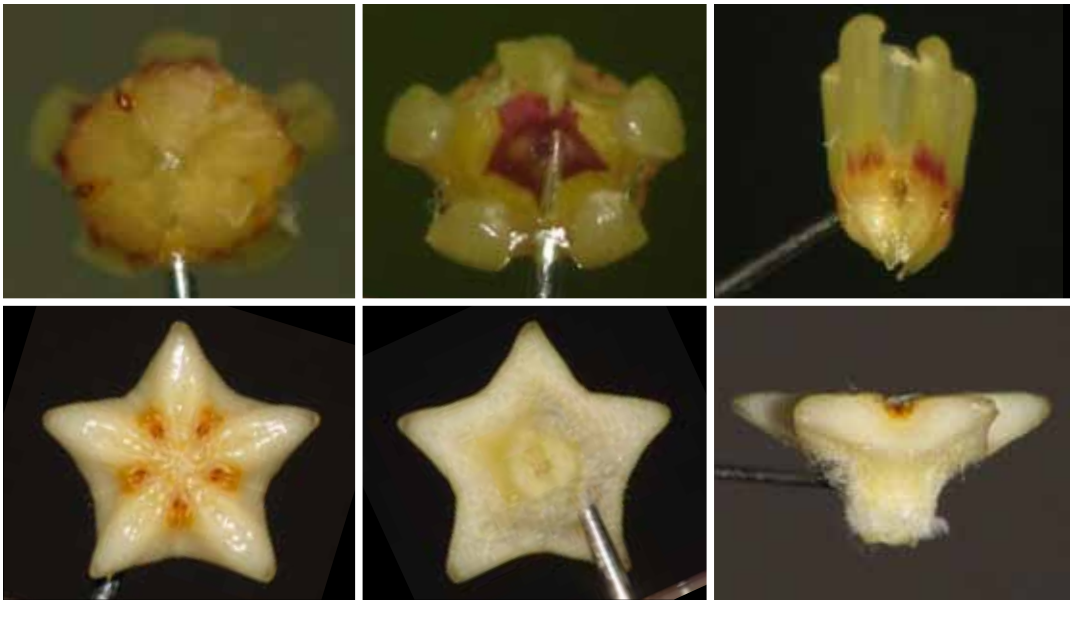


Fig. 81. Views of the coronas of *H. retrorsa* (above) and *H. spartioides* (below). From left to right: adaxial views of corona, abaxial views and side views, showing the large differences in the coronal lobes. Photos: A. Gavrus.

Fig. 82. Views of corolla and corona for *H. retrorsa* (above) and *H. spartioides* (below). From left to right: adaxial view showing the nearly free hirsute corolla lobes of *H. retrorsa* compared to the broad, triangular, and nearly glabrous corolla lobes of *H. spartioides*; abaxial view with long, curved glabrous pedicels and corolla lobes with revolute edges in *H. retrorsa* compared to the short, hairy pedicel and flattened lobes in *H. spartioides*, and thirdly, the side views of the pedicel, calyx, corolla and corona, with the long erect coronal lobes of *H. retrorsa* compared to the flattened coronas of *H. spartioides*. Photos: A. Gavrus.

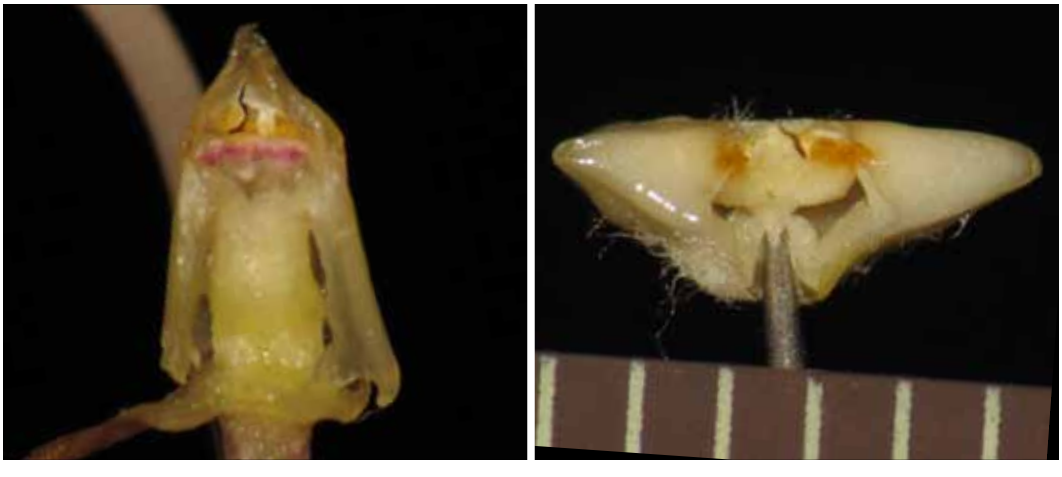


Fig. 83. Side view of corona with one lobe removed to show the central column, stigma head with coronal lobes on either side in *H. retrorsa* (left) and *H. spartioides* (right) . Photos: A. Gavrus.

Fig. 84 (left). Pollinarium of *H. retrorsa* (above) and *H. spartioides* (below). Both have rectangular-shaped pollinium but *H. retrorsa* has an obovate retinaculum compared to a rectangular-shaped one in *H. spartioides*. Photos: A. Gavrus. **Fig. 85** (right). The narrow, spindle-shaped, mottled follicle of *H. retrorsa*. Photos: Torrill Nyhuus.

1950/2010 on 4th May 2010), which has been made into the type specimen from accession no. H 46. As these areas are in lower montane or hill forest, not far from the Kalimantan and Sarawak borders, it may well be found in lower montane forest areas there.

The Sabah Forest Department has assessed this species under the category of Least Concern (LC) based on the criteria such as its relatively wide distribution (Ulu Tomani to Mount Lumatan), both in lower montane forest, in commercial forest reserves. The species AOO is 8 km^2. Though the original plants succumbed at the lower altitudes at Kipandi Park, it was successful in propagating the species from cuttings.

SPECIMENS EXAMINED—BORNEO. SABAH: Nabawan, Pensiangan, Mount Lumatan, 1300–1600 m, *Linus Gokusing* in Lamb *AL 1950/2010*, 4th May 2010 (holotype SAN, isotype SNP), (a living plant was established at Kipandi Park under accession H 46); Ulu Tomani, Tenom District, 1200–1300 m, *Linus Gokusing & Jongkir Lombika* in Lamb *AL 1341/2008* (SAN).

NOTES. We have been able to observe the growth and flowering of plants in cultivation at Kipandi, including three that were new young plants growing out of branch holes, over a period of three years.

Hoya spartioides also grows out of similar holes in trees in lowland forest, including heath forest, but also in the branches in the crowns of tall forest trees, and has similar long green terete peduncles. The other Sabah species, which are also generally epiphytic shrubs growing out of holes, include two new species, *H. ignorata* and *H. corymbosa* Rodda, Simonsson & Ercole (2013). Other species that have also been found growing out of holes in trees are *H. multiflora* Blume, and *H. lasiantha*, both epiphytic shrubs, that are also found in the forks of trees and on some tree trunks as epiphytic shrubs.

Hoya retrorsa is closely related to *H. spartioides* (Benth.) Kloppenburg (2001), in that both species have ant association. Both species start by producing a stem with quite broad leaves, which, in *H. retrorsa*, the initial leaves are elliptic but when new leaves are produced, they become narrower and eventually terete (Figs. 72A & 73). These terete leaves are sulcate (grooved) and 8–9 cm long. At the same time, long (up to 14 cm long), terete and green peduncles are formed which only produce a single flower at a time (Figs. 76 & 77). As the stems elongate and branch, many of the terete leaves fall off, leaving only green peduncles on quite long sections of the stem, indicating that they were then utilised for photosynthesis. So far, no other *Hoya* species except *H. spartioides* have these long peduncles that seem to be important for photosynthesis, and this feature may also not occur in other plant families. As each single flower is produced, the pedicel starts as straight and then, as the flower matures, the pedicels recurve, so the corona is pointing upwards (Figs. 72A, D–F, 76, 77 & 82). Whereas in *H. spartioides*, these initial leaves are thin-textured, and much broader, nearly three times the size of *H. retrorsa*. The new leaves in *H. spartioides* are very long

and terete; the photosynthesizing peduncles are nearly 20 cm long, producing 3–8, scented, orange flowers at a time on short, straight pedicels and no true leaves are produced as the stem elongates (Figs. 74, 75, 78 & 79). The pollinarium of these two species are very similar, in the shape of the pollinia (Fig. 84).

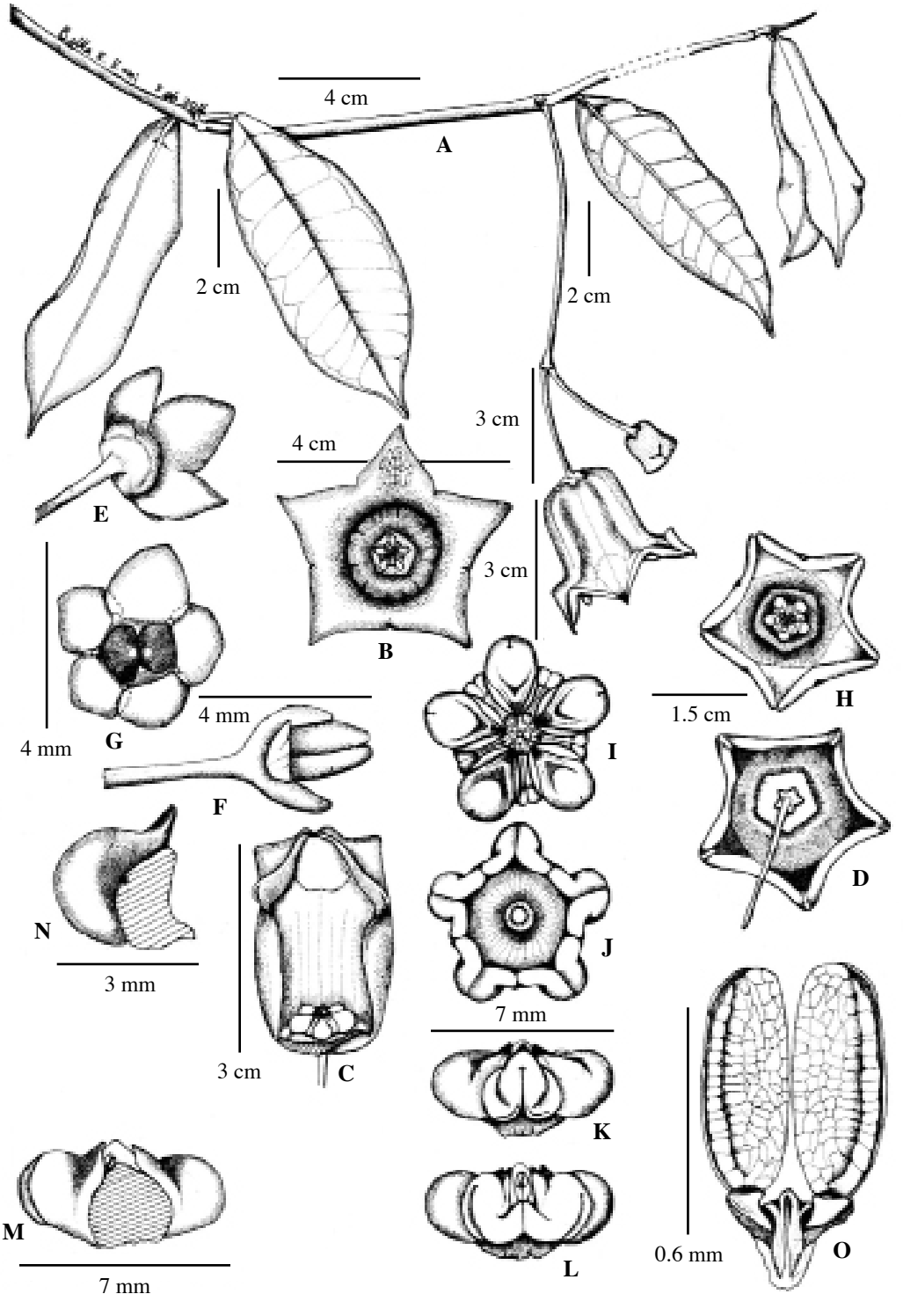
The corollas of the two species are quite different: *H. retrorsa* has long, nearly free corolla lobes, cream to tinged pink with white hairs on the adaxial surface and pink to red, glabrous on the abaxial surface (Figs. 78 & 82). Whereas, *H. spartioides* has short and bright orange saucer-shaped corollas which are glabrous throughout. The coronas are also very different: *H. retrorsa* has lobes that form a tall pyramid-shaped corona with no obvious visible guide lines between the outer lobes, while *H. spartioides* has laterally arranged ovate lobes with guide lines between the outer lobes (Figs. 78, 81 & 82). The guide line is utilised by insects to dislodge the pollinia from the clawed tarsi on the 'feet' of their legs.

7. Hoya sammannaniana *A. Lamb, A. Gavrus, B. Emoi & L. Gokusing* **sp. nov.**

H. wongii Rodda, Simonsson & L. Wanntorp, similis, sed planta inflorescentia floribus duo, flores c. 3.0 cm longum, 3–3.5 cm lata (nec flores singularis, c. 1.6 cm longum, 2.5–3 cm lata), lobis corollarum partim conflatis 1.7 cm longis, deinde lobis liberis (contra lobis corollarum penitus conflatis omnibus 3 cm longis, sine lobis liberis), exterior coronae rotundus (nec geminatus) differt. Typus: Linus Gokusing in Lamb AL 1649/2008, Borneo, Malaysia, Sabah, Beluran, Paitan river, c. 350 m altitude, 27th December 2008, cultivated at Kipandi Park, accession no. H 41 (holotypus SAN; isotypus SNP). **(Figs. 86, 87, 89, 96–100)**

Slender, epiphytic and terrestrial climber, to 5 m tall, glabrous; sap milky-white in all parts. **Stem** 3.5 mm thick, glabrous, bark brown to orange-brown; branching; basal stem with internodes 5–16 cm long with scattered adventitious roots; leafy branches with internodes green, 3–6 cm long, 2–3 mm thick, glabrous, with some adventitious roots. **Leaves** opposite; petiole grooved, green, sometimes tinged purple, 7–10 cm long, *c.* 0.2 cm thick, glabrous;

Fig. 86 (opposite). ***Hoya sammannaniana***. Botanical drawing by Bellia Emoi based partly on the type specimen in SAN, *Linus Gokusing et al.* in Lamb *AL 1619/2008* and living material at Kipandi Park, accession no. H 41, prior to the material being pressed. **A.** Flowering branch, peduncle with one open flower and one in bud. **B.** Looking into the campanulate flower. **C.** Cross-section of flower, to show the base of corolla or corolla tube with corona at the base. **D.** Flower from above, showing pedicel, calyx with small calyx lobes and campanulate corolla with margins of lobes revolute. **E.** Side view of pedicel and glabrous calyx, with overlapping calyx lobes. **F.** Side view of pedicel apex, calyx and bi-carpellate ovary. **G.** Top view of bi-carpellate ovary and calyx lobes. **H.** Corolla from adaxial side showing the corona. **I.** View from above the corona. **J.** View from below the corona. **K.** Side view of corona lobes. **L.** Side view of corona lobes and pollinarium. **M.** Cross-section of corona. **N.** Corona lobe from the side and attachment to back of anther (stamen). **O.** Pollinia showing pellucid edges, retinaculum, caudicles (clear) and narrow translators (stippled).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lamina elliptic to slightly oblong, thin, 8–10.6 cm × 2.6–3.8 cm, adaxial surface dark green, glabrous, abaxial surface light green, glabrous; base broadly tapering, apex shortly acuminate, to 1 cm long; mid-vein on adaxial surface shallowly impressed, secondary veins faintly visible, at about 80° to the mid-vein, forming loops to the margins of the lamina, abaxial veins prominent (Figs. 86A & 87). **Inflorescence** positively geotropic, 1–2 pendulous flowers, slightly sweet-scented, opening one at a time; peduncle persistent, green with purple markings, 4–7.5 cm long, 0.06–0.09 cm thick, glabrous; rachis extending up to 4 mm long over several years. **Flowers**: pedicels green, 2–3 cm long, 0.08–0.09 cm thick, glabrous; calyx pentamerous, green, 4–6 mm diameter, glabrous; calyx lobes overlapping, pink to green, sometimes with cream to white margins, apex obtuse, 1–1.5 mm × 0.5–1 mm; ovary bi-carpellate, conical, cream with greenish-white apex, *c*. 2 mm high, 1.5–2 mm diameter, glabrous (Figs. 86A, C–G & 96); corolla campanulate, 3–3.5 cm in diameter, abaxial surface pale cream to very pale yellow, often with a green tinge with scattered pink spots, especially on the basal area around the calyx, adaxial and abaxial surfaces glabrous; corolla base bell-shaped; corolla lobes fused for 1.5–1.7 cm, lobes spreading to upturned, 10–12 mm × 16–18 mm, apex acute to apiculate, slightly upturned, which turn downwards during the day, margins upturned to revolute (Figs. 86A–D, H, 87, 89 & 98); corona staminal 6.5–7 mm diameter; coronal lobes ovate, inner process base red, apex dark purple, acuminate, just above the outer process and below the apical anther appendage, *c*. 1 mm long, outer process cream to white at the base, inner sides and apical area red, *c*. 3 mm × 2 mm × 3 mm at the outer end, margins revolute; stigma head cream, tinged green, *c*. 2 mm high, *c*. 1.5 mm

Fig. 87 (left). *Hoya sammannaniana*. General view of stem, leaves and inflorescence with one tubular flower open, and a second in bud only. Photo: Anthony Lamb. **Fig. 88** (right). *Hoya patella* Schlechter, from Papua New Guinea has similar inflorescenses as *H. sammannaniana*, i.e., with only two flowers but the flowers in *H patella* are bowl-shaped and pink in colour. Photo: A. Gavrus.

Fig. 89 (left). Close-up of inflorescence of *H. sammannaniana* showing the glabrous cream-coloured campanulate flower, with the apices of the corolla lobes turned-up after opening. Photo: Anthony Lamb. **Fig. 90** (right). Close-up of inflorescence of *H. patella* showing the two bowl-shaped pink flowers, with red corona. Photo: A. Gavrus.

diameter (Figs. 86B,C & H, I–N, 97 & 99); pollinarium *c*. 0.8 mm long, pollinia oblanceolate to oblong, *c*. 0.59–0.6 mm × *c*. 0.23 mm, base and apex rounded, pellucid edges clear, crest present; caudicles scapula-shaped, *c*. 0.1 mm × 0.12 mm; translators long, slightly curved, *c*. 0.21 mm × 0.05 mm; retinaculum with broad distinct shoulders, *c*. 0.29 mm × 0.17 mm (Figs. 86O & 100). **Fruits** and **seeds** not seen.

ETYMOLOGY. The species is named after Datuk Sam Mannan, the Director of Sabah Forestry Department, who has championed sustainable forest management, the preservation of 55% of Sabah under a Permanent Forest Estate, and the conservation of totally protected areas.

ECOLOGY. The plant collected and established at Kipandi, from which the type specimen (*AL 1649/2008*) was made, came from hill dipterocarp forest that was being logged along the Paitan river in north-eastern Sabah (N.E. corner of Borneo), on sandstone sedimentary soils at about 300–400 m. The plant was an epiphyte growing from compost in a branch cavity on a large tree. The second specimen was found as a terrestrial climber to 2 m high, on a river bank, presumably in alluvial riverine forest in the Mount Palung National Park (S.W. corner of Borneo). It was collected by Cam Webb *et al*. at Gunung Palung National Park in West Kalimantan.

DISTRIBUTION AND CONSERVATION STATUS. Only two collections are known; the type being found along the river Paitan in Sabah, and a second specimen from Mount Palung in West Kalimantan, Indonesian Borneo.

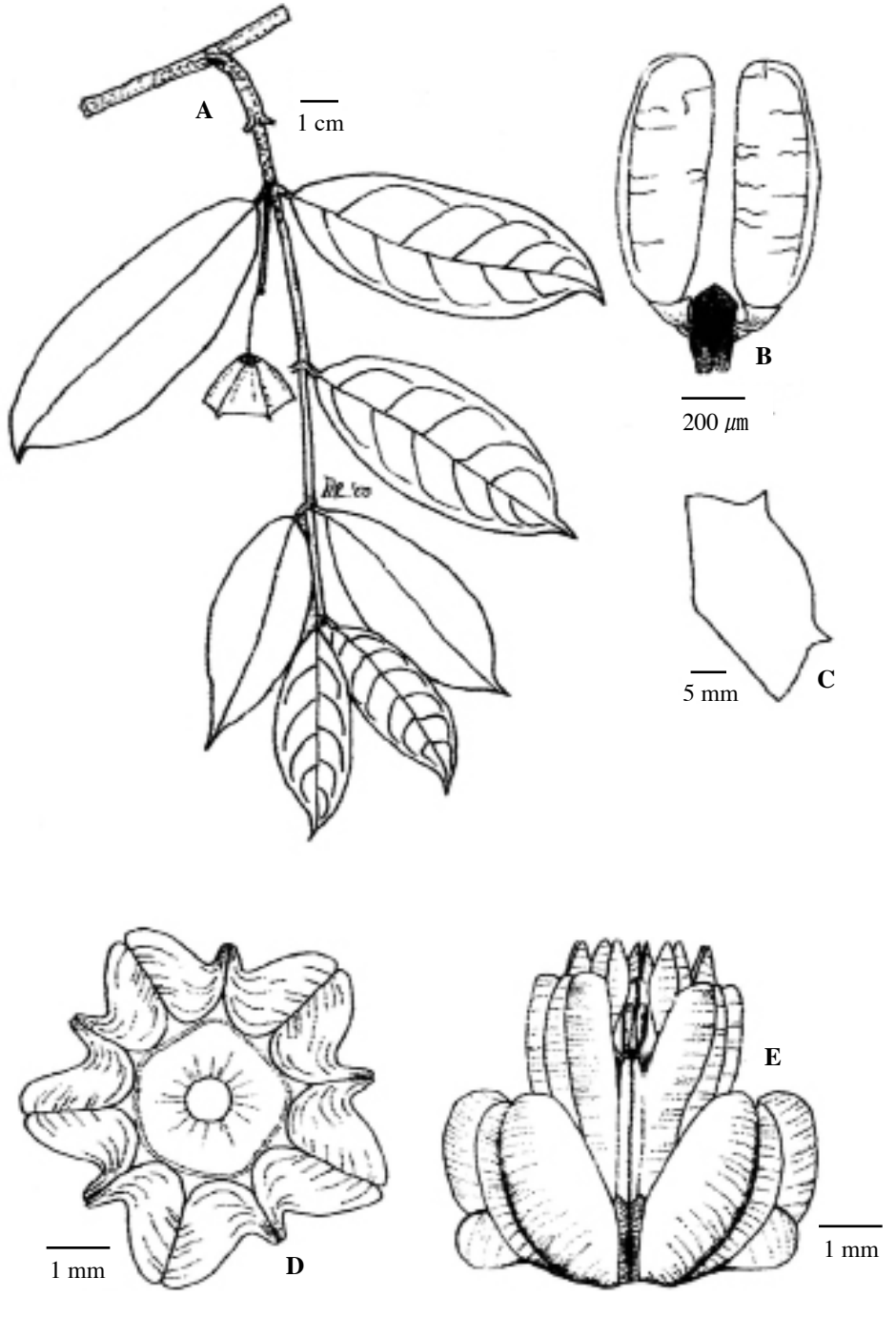


Fig. 91. *Hoya wongii,* Rodda, Simonssen & L.Wanntorp is one of the closest Bornean species from Brunei's heath forest, producing only a single tent-shaped flower, with a unique corona. Botanical illustration from Rodda *et al*. (2011).


Fig. 92 (left). The single-flowered inflorescence of *Hoya mappigera* which is closely related to *H. wongii* (Fig. 91). **Fig. 93** (right). Close-up of flower about to open in *H. mappigera*. Photos: Steven Chew.


Figs. 94 & 95. Close-ups of the corona of *H. mappigera* with erect mauve inner processes of the corona lobes and yellow outer processes. (left) side-view; (right) corona from above which is distinct from the corona of *H. wongii* (Fig. 91). Photos: Steven Chew.

The Sabah Forest Department has assessed this species as Vulnerable (VU), with Criteria D2 and also DD (Data Deficient) which is based on the huge distance between the only two restricted localities known. The species AOO is 8 km^2. The Indonesian population is in a well protected (National Park) whereas the Sabah population is within a deforested area, which is at risk. However, it is in cultivation, and being propagated, both at Kipandi Park and the Forest Research Centre.

SPECIMENS EXAMINED–BORNEO. SABAH: Beluran, Paitan, Sg. Paitan valley, *Linus Gokusing* in Lamb *AL 1649/2008*, 27th December 2008 (holotype SAN; isotype SNP). **KALIMANTAN:** Mount Palung, *Cam Webb, T. Triono, H. Yanto, E. Setiawan & B. Suryantoro,* (gp 0051), 1st February 2009 (BO).

Fig. 96. Apices of pedicels, calyx and bi-carpellate ovary. From left to right: adaxial views of sepals and ovary; abaxial views of apex of pedicel and calyx; and side-views of pedicel, calyx and bi-carpellate ovary of *H. sammannaniana* (above) and *H. patella* (below). Photos: A. Gavrus.

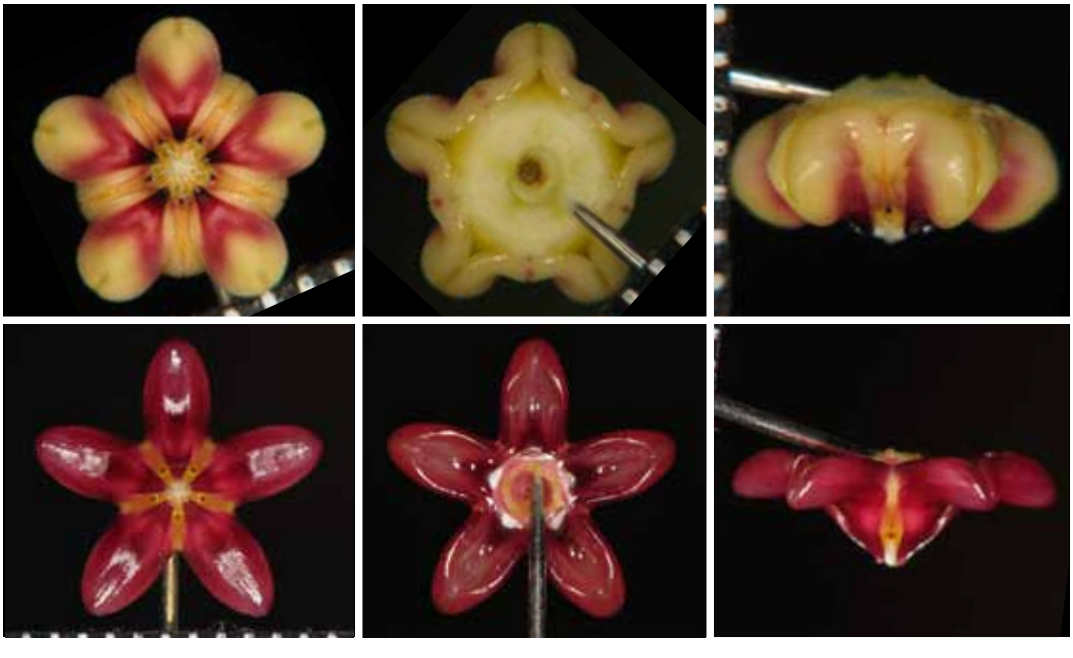


Fig. 97. Views of the corona of *H. sammannaniana* (above) and *H. patella* (below). From left to right: adaxial views, abaxial views and side views. Photos: A. Gavrus.

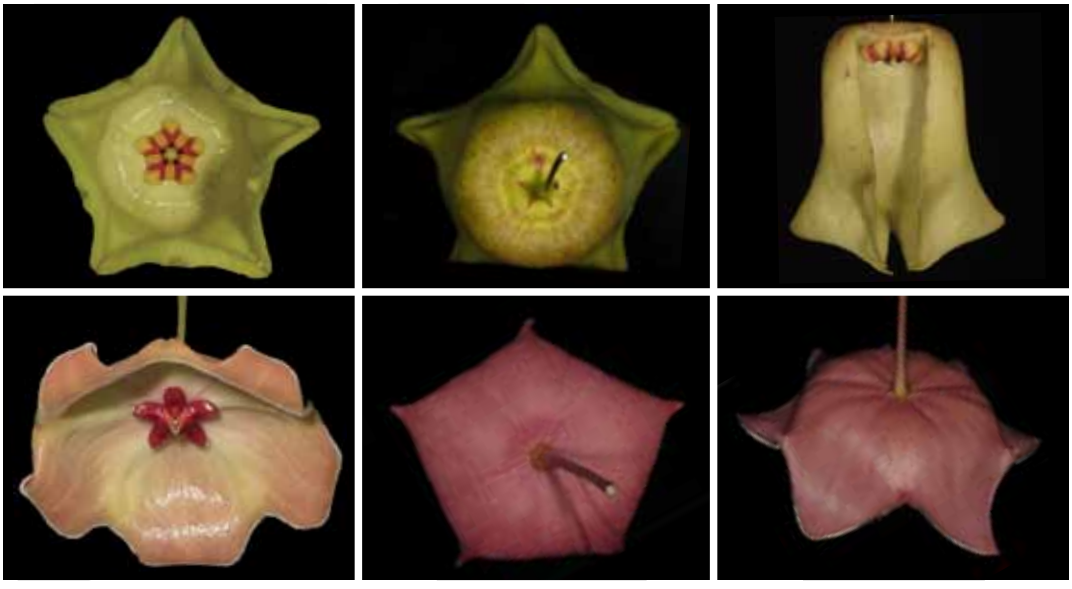


Fig. 98. Views of corolla and corona for *H. sammannaniana* (above) and *H. patella* (below). From left to right: adaxial views showing tubular base of corolla and revolute margins of the corolla lobes of *H. sammannaniana*, compared to the bowl-shaped base, with corolla lobes without revolute margins for *H. patella*; abaxial views showing pedicels, calyx sepals and corolla lobes of corolla with revolute margins for *H. sammannaniana* but not in *H. patella*; and side view of the tubular corolla base and lobes with one side removed for *H. sammannaniana* to show the corona compared to the more bowl-shaped base and corona of *H. patella* below. Photos: A. Gavrus.

Fig. 99. *H. sammannaniana* (above), *H. patella* (below). From left to right: side view of corona with one lobe removed to show the central column and stylar head with coronal lobes on either side; and right, the corolla surface below the corona. Photos: A. Gavrus.

Fig. 100. Pollinarium of *H. sammannaniana* (left), and *H. patella* (right); both showing distinct differences in the shape of the pollinium with wide pellucid edges and distinct crest in *H. patella*, which also has a more flattened top to the pollinium. The retinaculums are very different with distinct head and shoulders, and translators in *H. sammannaniana*. Photos: A. Gavrus.

NOTES. The type specimen, *Linus Gokusing* in Lamb *AL 1649/2008*, from the River Paitan, with living material established at Kipandi, observed over a period of three years, was the material from which the species description and the botanical drawings were made. Several species with only one or two flowers per inflorescence can be compared to *H. sammannaniana*.

Hoya sammannaniana is clearly closely related to *H. wongii* Rodda, Simonsson & L. Wanntorp (2011), that was collected in the heath forest of Pasir Puteh (Fig. 91), in the Tutong District of Brunei. The stems and leaves of both species are very similar except that no adventitious roots were observed on the internodes of *H. wongii*. The main differences are that *H. wongii* produces only a single flower at a time, and that though the campanulate corolla has lobes fused for the whole length, up to 3 cm, the shape is more like a 'tent' (mostly 2 flowers produced but only one flower open at a time and the corolla lobes fused for up to 1.7 cm in *H. sammannaniana*), the corolla diameter is 2.5–3 cm across (3–3.5 cm across in *H. sammannaniana*). The flowers of *H. wongii* are yellow compared to creamy-white with scattered pink spots in *H. sammannaniana*. The main difference is in the corona as *H. wongii* has a unique corona without a skirt, with a more erect corona, to *c*. 6 mm high with broadly inflated outer processes and laterally compressed inner processes with two bi-

dentate appendages (Fig. 91). This compares to *H. sammannaniana*, in that although it has no skirt, it resembles other campanulate species in having laterally spreading ovate coronal lobes, 3–4 mm high, and no appendages.

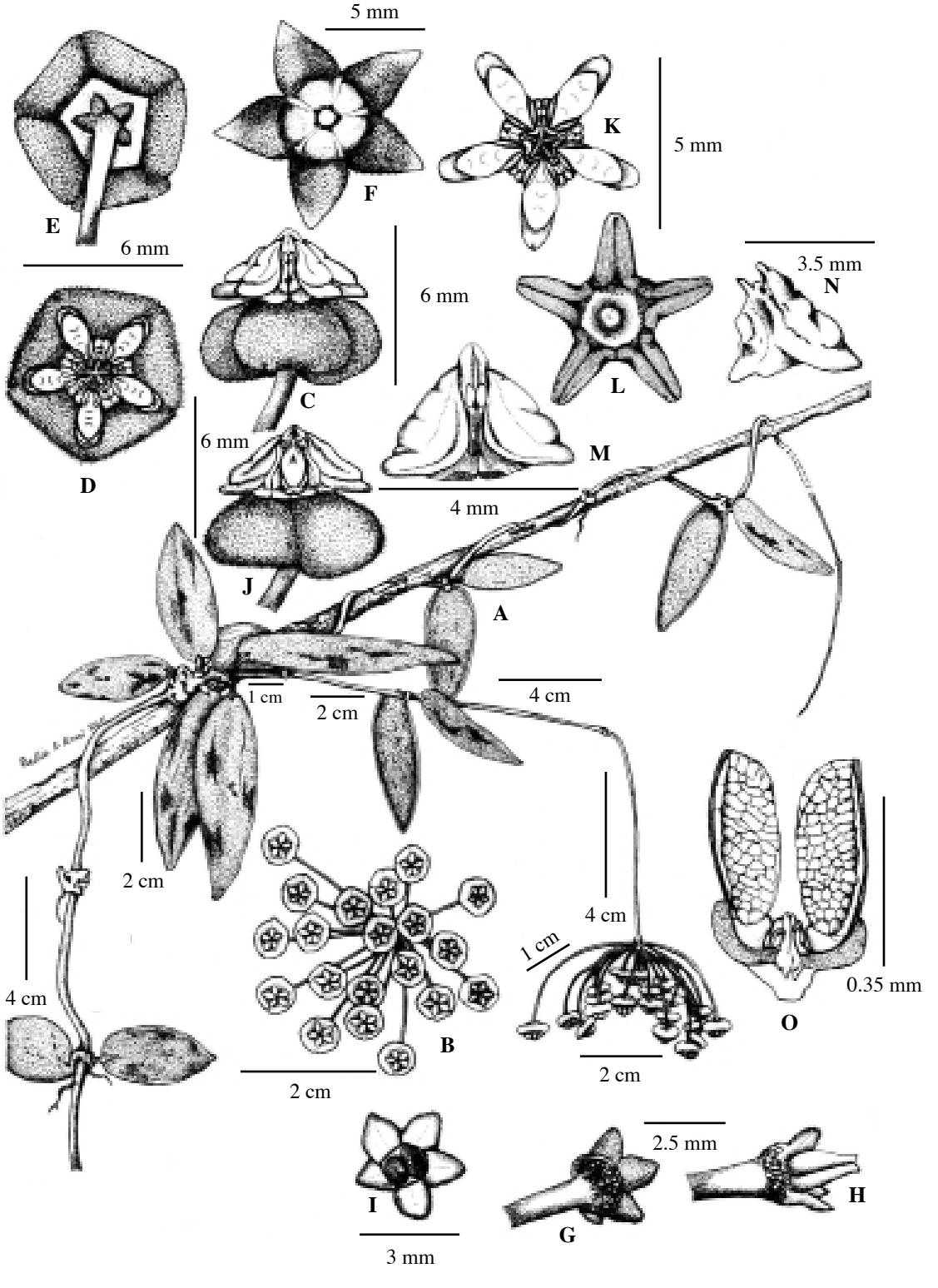
Very recently, another white, single-flowered species, *Hoya mappigera* M. Rodda & N. Simmonson Juhonwe, was discovered near Kalabakan on the East Coast of Sabah (*Linus Gokusing* in Lamb *AL 2316/2012* of 12/07/2012, Borneo, Malaysia, Sabah), which has a tent-like corolla with similar leaves, but distinctly different mauve and yellow-coloured corona, compared to both *H. sammannaniana* and *H. wongii* (Figs. 92–95).

H. sammannaniana is also similar to *H. patella* Schlechter, from Papua New Guinea which also has inflorescences of two flowers, but with more bowl-shaped campanulate flowers that are pink with a red corona (Figs. 88 & 90). In *H. patella*, both flowers open at the same time whereas in *H. sammannaniana*, the flowers open at different times. The two species have distinctly different coronas and pollinia (Figs. 97–99).

8. Hoya sigillatis ssp. **paitanensis** *A. Gavrus, A. Lamb, B. Emoi & L. Gokusing* **ssp. nov.**

Hoya sigillatis T. Green similes sed plantae folium incrassatum viride margine purpurato (nec folium tenuis et sigillatum) et floris coronae lobi forma differt. Typus: Linus Gokusing & Jongir Lombika et al. in Lamb AL 1757/2009, Borneo, Malaysia, Sabah, Beluran, the valley of the river Paitan, c. 300 m altitude, 10th April 2011, cultivated at Kipandi Park, accession no H 29 (holotypus SAN; isotypus SNP). **(Figs. 101, 102, 104, 106 & 108–112)**

Epiphytic climber, with thin twining stems, to 3 m tall, glabrous; sap milky-white in all parts. **Stem** 1.5–2 mm thick, bark corky-greyish, older basal internodes 1–5 cm long with adventitious roots; leafy branches with young internodes green to purple, 2–6 cm long, 1 mm thick, nodes 3–4 mm diameter, with adventitious roots along internodes and at nodes. **Leaves** opposite; petiole grooved, purple to grey, 0.4–0.5 cm long, 0.1–0.15 cm thick, glabrous; lamina oblong to elliptic, becoming linear on older stems, stiff, thick, 4–5 cm × 0.9–1 cm (elliptic/ovate lamina), to 6–10 cm × 1.0–1.2 cm (linear lamina), glabrous, adaxial surface dark green, tinged with purple, base rounded, apex acute, margins purple, slightly revolute, forming a stiff edge; mid-vein or secondary veins not visible (Figs. 101A, 102 & 104). **Inflorescence** positively geotropic, concave-shaped umbel of 15–25 flowers, 4–5 cm in diameter, with no scent detected; peduncle persistent, pendulous, purple to grey-green, 5–6 cm long, 0.1–0.15 cm thick, glabrous; rachis producing a series of umbels of flowers extending to *c.* 0.2 cm long (Figs. 101A–B & 106). **Flowers**: pedicels pinkish-purple with darker purple spots, curved, inner pedicels of umbel 1–2 cm long, *c.* 0.09 cm thick, outer pedicels 3–5 cm long, *c.* 0.09 cm thick, glabrous, forming a concave umbel of flowers; calyx pentamerous, greenish-red to reddish, *c.* 1.5 mm diameter, with colleters; calyx lobes apex obtuse, slightly overlapping at base, red with lighter translucent edges, *c.* 1 mm × 0.8 mm,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G
2.5 mm
H

Fig. 101 (opposite). ***Hoya sigillatis* ssp. *paitenensis***. Botanical drawing by Bellia Emoi based partly on the type material, *Linus Gokusing et al*. in Lamb *AL 1757/2009*, and living material cultivated at Kipandi Park accession no. H 29, prior to specimens being pressed. **A.** Flowering branch with positively geotropic peduncle, and concave umbel of flowers, with many juvenile elliptic leaves possessing slightly revolute and thickened lamina margin on the abaxial surface of the lamina, and a mature linear leaf. **B.** Inflorescence from below. **C.** Flower, side view showing apical part of pedicel, pubescent and revolute margin of corolla lobes, and corona with coronal skirt. **D.** Flower from below showing pubescent base of corolla and the corona. **E.** Flower from above showing apical part of pedicel, minutely pubescent calyx lobes with revolute margins, adaxial surface of corolla lobes pubescent and abaxial surface of central area of corolla glabrous. **F.** Corolla flattened out showing adaxial surface of lobes pubescent, glabrous apices and glabrous central corolla area under the corona. **G.** Apex of pedicel showing colleters, with calyx lobes minutely pubescent on the adaxial surface. **H.** Apex of pedicel calyx with colleters and glabrous bi-carpellate ovary. **I.** Bi-carpellate ovary and glabrous abaxial surface of the calyx lobes viewed from above. **J.** Another side view of the flower, with corona, showing the coronal anther skirt of the outer process. **K.** Corona from above, showing the extended coronal anther skirt. **L.** Corona from below. **M.** Side view of corona lobes and position of pollinarium, anther appendages, and coronal anther skirt. **N.** Corona lobe showing inner and outer processes and attachment to the back of the staminal column with anther appendage below the inner process and the coronal skirt. **O.** Pollinia showing pellucid edges with wings, retinaculum, caudicles (clear) and large curved translators (stippled).

Fig. 102 (left). *Hoya sigillatis* ssp. *paitanensis*. General view of a plant and leaves, cultivated at Kipandi.
Fig. 103 (right). *Hoya sigillatis* Green. General view of a plant and leaves in the *Hoya* collection at the Agricultural Park, Tenom. Photos: A. Gavrus.

adaxial surface with colleters and minute pubescence, abaxial surface glabrous; ovary bicarpellate, skittle-shaped (lageniform), *c*. 2 mm high, *c*. 0.8 mm diameter, basal part cream to pinkish, apices white, glabrous (Figs. 101E, G–I & 108); corolla campanulate, corolla with revolute margins *c*. 6 mm × 2 mm (when lobes flattened, corolla 9–11 mm diameter); corolla base flat to slightly saucer-shaped, area of corolla base under corona for 1.5 mm, darker pink, glabrous; corolla lobes triangular, *c*. 5 mm × 4 mm, adaxial surface pale pink, minutely pubescent (whitish hairs), apex 1 mm from the tip paler, glabrous, abaxial surface pale pink to cream, darker pink under the calyx, glabrous throughout, apex acute (Figs. 101C–F, J & 109); corona staminal *c*. 2 mm high, *c*. 5 mm diameter; coronal lobes oblong at the base (includes the coronal skirt), cream, wide, the revolute edges of the outer coronal skirt forming the coronal groove, skirt obtuse (from underneath); inner process reddish-purple, *c*. 1 mm × 1 mm, outer process base and anther wings reddish purple, *c*. 3 mm × 1 mm, sits on a wider skirt with a fold in the middle section of the outer process, outer and inner processess apices ovate; anther appendages white, above the stigma head; stigma head cream to white (Figs. 101D, C, J–N, 110 & 111); pollinarium *c*. 0.5 mm long, pollinia oblong, *c*. 0.39 mm × 0.16 mm, base rounded, apex flattened at an angle, pellucid edge clear, crest present; caudicles triangular to scapula shaped, *c*. 0.1 mm × 0.09 mm; translators

Figs. 104 & **105.** Close-up of leaves of *H. sigillatis* ssp. *paitanensis* (left) compared to the leaves of *H. sigillatis* ssp. *sigillatis* (right) at the Tenom Agricultural Park. Photos: Anthony Lamb (left) and A. Gavrus (right).

curved, sickle-shaped, narrow at the retinaculum, to much broader at the apex, *c*. 0.17 mm × 0.03 mm; retinaculum pyramid-shaped, *c*. 0.16 mm × 0.08 mm, with no distinct shoulders (Figs. 101O & 112). **Fruit** and **seeds** not seen.

ETYMOLOGY. The subspecies is named after the Paitan river in Sabah, where the species was collected in the hill forest above the river. The plant was cultivated at Kipandi Park (accession no. H 29).

ECOLOGY. It is epiphytic in hill dipterocarp forest that was being logged, on the valley slopes (*c*. 300 m altitude), above the Paitan river. The forest is on sedimentary sandstone soil (L. Gokusing, *pers. obs.*)

Figs. 106 & **107.** Close-up of inflorescence of *H. sigillatis* ssp. *paitanensis* (left) and *H. sigillatis* ssp. *sigillatis* (right). Photos: Anthony Lamb.

DISTRIBUTION AND CONSERVATION STATUS. This taxon is only known from Sabah thus far. It was collected on the slopes of the valley above the Paitan river at about 300 m altitude, which is in the N.E. of Sabah in the Beluran district, in which another specimen was also found. It has probably been overlooked, and probably has a much wider distribution.

Hoya sigillatis ssp. *paitenensis* is only known from two localities, until further collections provide more information on its distribution. In its present localities, it is threatened by forest clearing for agricultural development.

The Sabah Forest Department has assessed this taxa as Vulnerable (VU) with the criteria D2, based on the very few specimens identified, in a restricted area, where the forest is

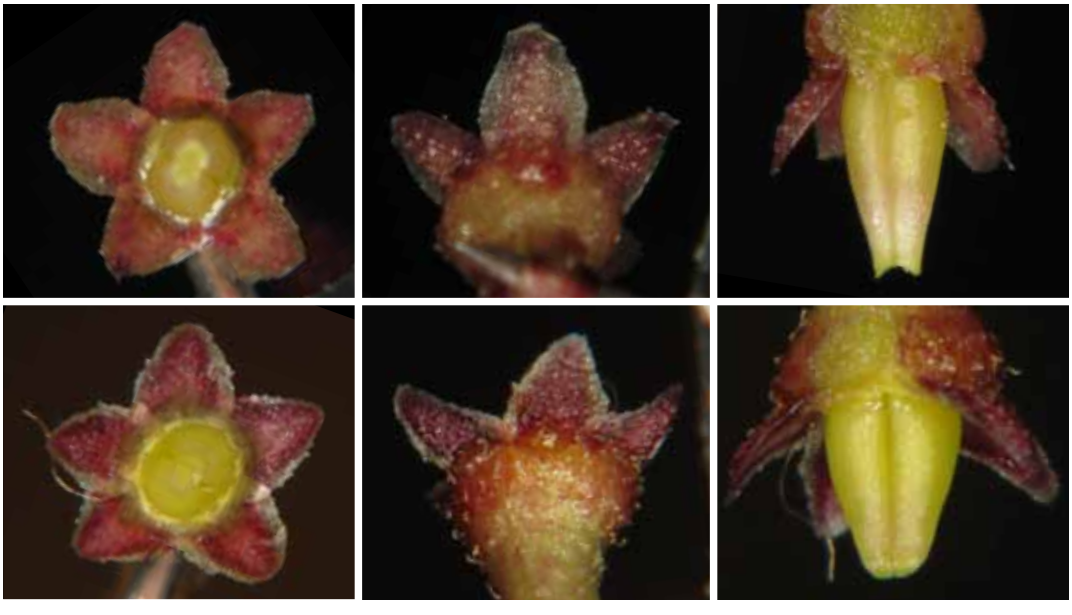

Fig. 108. Apices of pedicels, calyx, colleters and bi-carpellate ovary. From left to right: adaxial views of sepals and ovary; abaxial views of pedicel apex and calyx; side-views of pedicel apex, calyx, colleters and bi-carpellate ovary of *H. sigillatis* ssp. *paitanensis* (above) and *H. sigillatis* ssp. *sigillatis* (below). Photos: A. Gavrus.

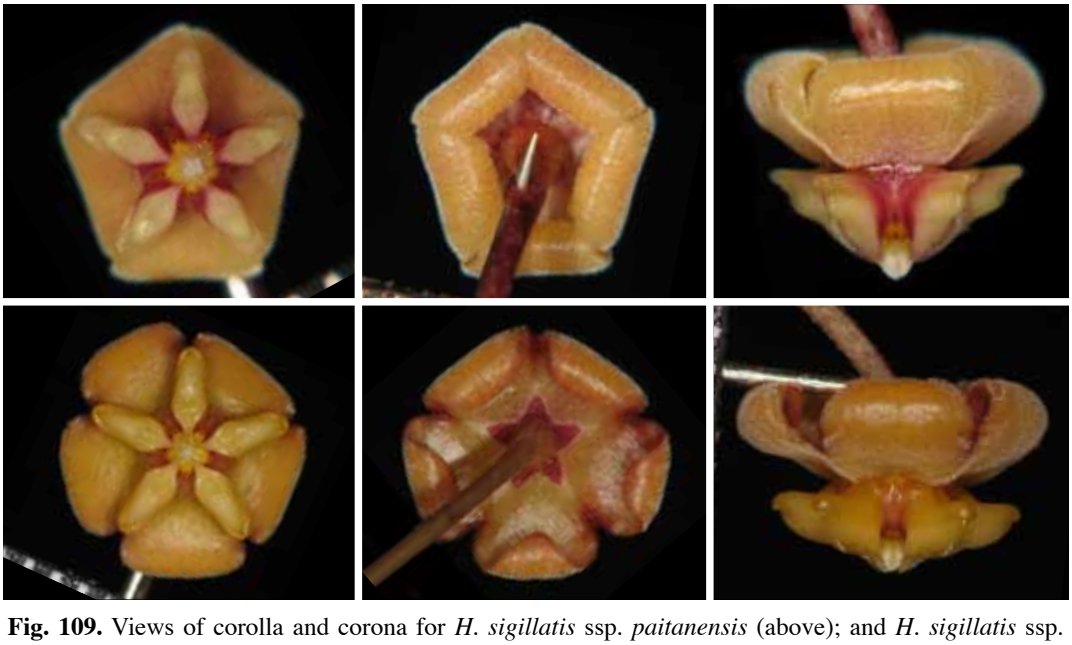

Fig. 109. Views of corolla and corona for *H. sigillatis* ssp. *paitanensis* (above); and *H. sigillatis* ssp. *sigillatis* (below). From left to right: adaxial views showing the pink, pubescent, revolute corolla lobes and pink and cream corona lobes, for *H. sigillatis* ssp. *paitanensis*; compared to the more apricot-coloured corolla with a white and yellow corona for *H. sigillatis* ssp. *sigillatis*. Photos: A. Gavrus.

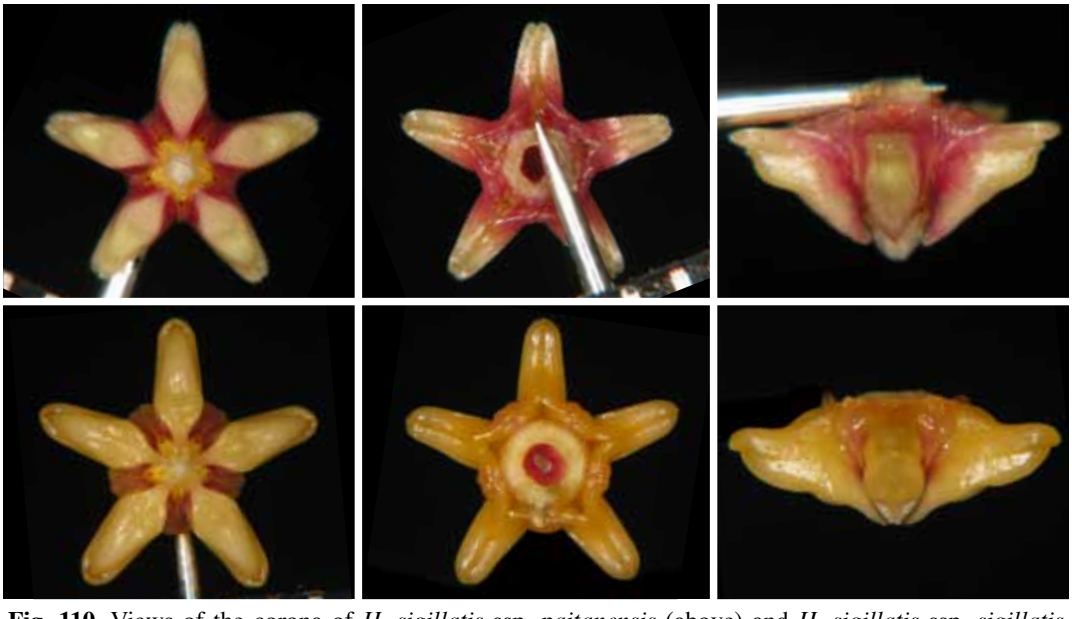

Fig. 110. Views of the corona of *H. sigillatis* ssp. *paitanensis* (above) and *H. sigillatis* ssp. *sigillatis* (below). From left to right: adaxial views, abaxial views and side views of the latter showing the different shapes of the coronal lobes . Photos: A. Gavrus.

Fig. 111. *H. sigillatis* ssp. *paitanensis* (above) and *H. sigillatis* ssp. *sigillatis* (below). From left to right: side view of corona with one lobe removed to show the central column and stylar head, with coronal lobes on either side; and right, the corolla surface below the corona. Note the much narrower, pointed, inner process with a small hump at the base in *H. sigillatis* ssp. *paitanensis* compared to the thicker, more rounded apex of the inner process with no hump for ssp. *sigillatis*. Photos: A. Gavrus.

Fig. 112. Pollinarium of *H. sigillatis* ssp. *paitanensis* (left) and *H. sigillatis* ssp. *sigillatis* (right), which are very similar except for the shapes of the retinaculum, with more obvious 'shoulders' in *H. sigillatis* ssp. *sigillatis*. Photos: Anthony Lamb (left) and A. Gavrus (right).

being converted to agricultural development. The species has an AOO of 8 km^2. This species is easily confused with several other unnamed *Hoya* species, and it has probably been overlooked in many herbaria, and more specimens need to be collected to get a better picture of its distribution. Otherwise, this taxa could easily be placed into the category Critically Endangered (CR) under the criteria B2 based on its very restricted known distribution. However, the species is being propagated at Kipandi Park.

SPECIMENS EXAMINED—BORNEO. SABAH: Beluran district, Paitan, Sg. Paitan valley, *c*. 300 m, *Linus Gokusing & Jongir Lombika et al*. in Lamb *AL 1757/2009*, (holotype SAN; isotype SNP), (a living plant was established in Kipandi Park under accession no. H 29); Batu Panadawan, Ulu Sg. Ogan, *Aban et al*. SAN 67036, 25th September 1984 (SAN).

NOTES. We were able to compare the type of this taxa to specimens of *H. sigillatis* T. Green (2004), established in Ben Chai's collection in Tuaran (Gavrus A 608-15), and *AL 1760/2009* of 14/4/2009, Borneo, Malaysia, Sabah, Tuaran cult. B. Chai, (SAN), and a specimen of this species from the original collection established in the Tenom Agricultural Park *Hoya* collection. The latter came from the original type material for that species, collected by T.

Green, see *AL 2019* of October 2010, Borneo, Malaysia, Sabah, cult. Tenom (SAN), which occurred in heath forest at 450 m at Nabawan. The specimens have been lodged in the Sandakan Herbarium (SAN).

Hoya sigillatis ssp. *paitanensis* has small flowers, arranged in concave umbels, with pubescent, revolute corolla lobes that can be confused with many similar species. However, many of these species have distinctly different leaves, ovate to lanceolate, with either much smaller leaves such as *H. sipitangensis* Kloppenburg & Wiberg, or larger, lanceolate to elliptic, leaves such as *H. nabawanensis* Kloppenburg & Wiberg. However, the flowers of those species are completely different from *H. sigillatis* ssp. *paitanensis*.

Hoya sigillatis ssp. *paitanensis* is closest to *H. sigillatis*, having very similar thin twining stems, with older leaves that are linear to oblong, thick, stiff and with no visible mid-veins, and both taxa, very often have a purple edge to the leaf. However, *H. sigillatis* leaves are more grey-green, and covered in silvery to white markings or purple markings, whereas only small purple blotches are found in *H. sigillatis* ssp. *paitanensis*. Both, have leaves that exceed 7 cm in length, but *H. sigillatis* has leaves described as 3.5–10 cm × 1–1.8 cm (it was measured as exceeding 2 cm in width in the Tenom collection, where the plant described by T. Green is growing). *Hoya sigillatis* ssp. *paitanensis* leaves are narrower, to 1.2 cm wide. Both, have positively geotropic concave umbels of about 20 flowers of similar size, with revolute corolla lobes. Both taxa have a similar calyx, but *H. sigillatis* ssp. *paitanensis* has a longer bi-carpellate skittle-shaped ovary, *c*. 2 mm long compared to *H. sigillatis* which has an ovate ovary which is *c*. 1.5 mm long (1.5 mm measured in Tenom) (Figs. 101H & 108). Both taxa have flowers with minutely pubescent corolla lobes, pinkish-cream corolla, and a white and pink corona on *H. sigillatis* ssp. *paitanensis*, whereas *H. sigillatis* has a more apricot-coloured corolla with a white and yellow corona. Both taxa have minutely pubescent adaxial surfaces of the corolla with glabrous apices. The shapes of the corona lobes for the two taxa are also distinct. *H. sigillatis* has much more flattened corona lobes. From above, the corona lobes of *H. sigillatis* ssp. *paitanensis* are more ovate; in *H. sigillatis,* the lobes are more oblong to linear (Figs. 110 & 111). In *H. sigillatis* ssp. *paitanensis,* the corona has an extended skirt-like extension on the lower lobes, but on *H. sigillatis*, the skirt is not so obvious (Figs. 109 & 110).

CONCLUSION

Four of the new *Hoya* species described, that is, *H. hamiltoniorum*, *H. kipandiensis*, *H. retrorsa* and *H. sammannaniana,* have added a whole range of new characters, not seen in other species so far found in Sabah. This emphasises the great diversity of species with special characters found in Borneo as a whole. To this, we can add other new species recently described for Borneo, such as, *H. danumensis* Rodda & Nyhuus (2009) in Sabah; *H. wongii* Rodda, Simonsson & Wanntorp (2011) in Brunei, and *H. devogellii* Rodda & Simonsson

(2011a) and *H. medinillifolia* Rodda & Simonsson (2011b) from Sarawak and Sabah, and *H. mappigera* M. Rodda & N. Simonsson (2011c) from Peninsular Malaysia and Sabah.

Furthermore, two small epiphytic shrub species that are found growing out of holes in branches of understorey trees with an ant association, and with very small flowers, have been discovered in Sabah; one in hill *kerangas* forest at 450 m (also found in Peninsular Malaysia and Vietnam), *H. ignorata* Tran *et al*. (2011); and a second, even smaller species, *H. corymbosa* (Rodda, Simonsson & Ercole 2013), from the lower montane forest in Sabah. Both of these were also established at Kipandi Park. However, the latter did not survive the lower altitude.

The wealth of new features in the Borneo species has added valuable information for a fuller understanding of the genus *Hoya* as a whole. Such a diversity of species in Sabah and Borneo might well indicate Borneo as a centre of origin for the genus, but this has to be verified by further molecular work on all the species not yet covered.

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Additional Notes on *Diplycosia mantorii* Argent (Ericaceae) Endemic to Sabah

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Summary. *Diplycosia mantorii* has been refound on Gunung Alab on the Crocker Range growing as a small terrestrial population. The sites have been revisited to collect both flowering and fruiting material. A full description is now given including that of flowers which are recorded for the first time. The habitat is discussed and a couplet provided for updating the key to *Diplycosia* of Borneo (Argent, 1989).

Diplycosia is a poorly known genus of the Ericaceae restricted to SE Asia. Its main centre of diversity is the island of Borneo where nearly half the known species occur (Sleumer, 1967). It is particularly well represented in Sabah with Mount Kinabalu being the richest single location with 27 species recorded (about one quarter of the genus) (Beaman *et al*., 2001). Many of the species are inadequately known and this article more fully describes *Diplycosia mantorii* Argent which was hitherto only known from a single herbarium collection. Refinding this poorly known species from a new locality has confirmed its identity as a good species and allowed a fuller description including that of the flowers.

D. mantorii was described in 2002 from a single herbarium collection made by Asik Mantor (SAN 113779) from Tunggol FH, Km 45, Jalan Kota Kinabalu although another collection (*Argent 25108518),* from much further south at Long Pa Sia, in the Sipitang District, was tentatively linked to this species although having much larger leaves (Argent, 2002). It would now seem doubtful if the Long Pa Sia specimen is the same species. On a field excursion to Gunung (Mount) Alab in 2008 by the authors, more material of what seemed be a new species was found, first alongside the track to the Gunong Alab field station just above the main road at *c*. 1600 m and then further specimens were seen around the field station itself. This material was without flowers. The site was revisited the second author

(Lamb) on several occasions until flowering material was finally obtained on 18 May 2009 so that drawings could be made and the description completed. It was realised then that it was not new, but a new record for *Diplycosia mantorii*, a considerable distance from the type locality and more certainly establishing this as a good species in the Sabah flora. The original description of this species was of a climber up to 4 m. This now seems somewhat doubtful although it could have been a hemi-epiphyte rooting along the branches and trunk of the host tree when it might have become quite sprawling.

A population of about 12 plants was noted in the rough grassland with occasional shrubs alongside the track to the Alab field station. They were all erect shrubs growing to *c*. 1 m high and a further four plants were found in the immediate vicinity of the field station. They showed little variation. It is likely that the reason that this species remained uncollected for so long because it is usually epiphytic, growing high in the branches of trees in the montane forest, but like many other normally epiphytic Ericaceae it will grow terrestrially given sufficiently open conditions. The removal of the forest along the roadside and the thinning around the field station provide just such open conditions for epiphytes to establish on the ground. It still remains to be more directly observed, however, if this species is normally epiphytic. It is, in any case, very inconspicuous with its small green leaves and flowers. For a further discussion on the possible relationships of this species see Argent (2002). Reference specimens are lodged in the Sandakan Herbarium (SAN): Lamb *AL 1795/2009* (flowering) and *AL 1389/2008* (fruiting). The species is named after the first collector, Asik Mantor.

In the key to *Diplycosia* in Borneo (Argent, 1989) it keys easily to couplet 32 where on balance of the majority of leaves being less than 2 cm long it would key to couplet 34. Here a new couplet 32A should be inserted:

- 32A Plants lacking bristles, having only short white hairs on the stems *D. mantorii*.
- 32A+ Plants with bristles on the young stems 34.

Diplycosia mantorii Argent (Named after the original collector, Asik Mantor).

Type: Borneo, Sabah, Penampang District, Tunggol FH, Km 45, Jalan Kota Kinabalu, *c*. 6° 14'N. 116° 25'E 17th July 1986, *Asik Mantor SAN 113779* (holo K; iso KEP, SAN). **Figs. 1–3.**

Erect shrub to *c*.1 m tall. Branches laxly leafy, the leaves spirally arranged. Stems covered in a very short (*c*. 0.02 mm) rigid, patent, pubescence together with a few much longer caducous, glandular hairs on the youngest stems but no bristles. Petiole often red, 1.5–2 mm × *c*. 1 mm, weakly grooved above, with the same short pubescence as the stems. Leaf blade elliptic, 13–25 mm × 5–12 mm, glabrous above with a distinctly finely undulate surface when dry, somewhat irregularly punctulate below, puncta representing gland bases, lamina, coriaceous; base broadly cuneate; margin more or less entire when mature and very

Fig. 1 (left). Close-up of the fruits of *Diplycosia mantorii* taken on Mount Alab at *c*. 1600 m. Photo: A. Phillipps. **Fig. 2** (right). General view of a shrub of *Diplycosia mantorii* on Mount Alab in the centre of Crocker Range, Sabah. Photo: A. Lamb.

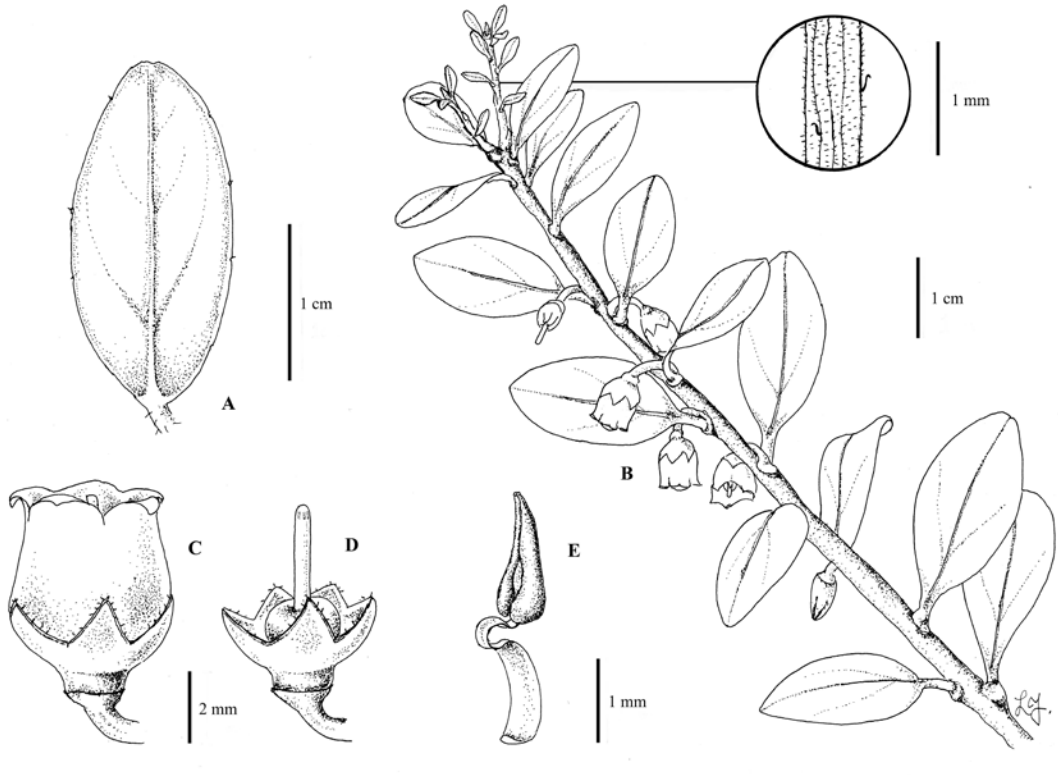

Fig. 3. *Diplycosia mantorii*. **A.** single leaf. **B.** Branch habit with insert showing indumentum on the young stem. **C.** Flower. **D.** Pistil with calyx attached. **E.** Stamen.

slightly revolute but finely denticulate when young with glandular hairs in the angles, these sometimes leaving minute spots after being shed; the apex rounded, sometimes mucronate and/or retuse, the terminal gland occasionally conspicuous but mostly obscure; midrib slightly depressed but mostly rather obscure above, slightly raised and much more distinct below, lateral veins almost entirely obscure, occasionally 1–2 traces from near the base arching upwards. Flowers solitary, mostly from upper leaf axils; pedicels short and slender, 2–3 mm × 0.5 mm, covered with fastigiate glandular hairs. Bracteoles small, *c*. 0.5 mm wide, ± semi-circular and fimbriate round the edges. Calyx green tinged with purple at the apex, 3–4 mm, the tube *c*. 2 mm, glabrous, the lobes *c*. 2 mm, triangular with broadly acute points, densely hairy and glandular along the margins otherwise glabrous, without any distinctively large gland at the apex. Corolla green *c*. 5 mm × 4 mm, glabrous both inside and out; stamens *c*. 4.5 mm, the filaments white, glabrous, linear, sigmoid; anthers orange-brown, *c*. 3 mm, the tubules, straight, erect *c*. 1.5 mm, both tubules and anther sacs appressed. Disc glabrous; ovary *c*. 2.5 mm × 2 mm, with long but rather sparse erect hairs on the upper half, style *c*. 2.5 mm long, with a few appressed hairs near the base, otherwise glabrous. Fruit (including accrescent calyx) grey-black, the lobes fully covering the ovary, *c*. 10 mm × 8 mm.

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CONTENTS

Front cover: *Hoya sammanniana*, close-up of the bell-shaped flower, this species was discovered in the Sg. Paitan Valley, Sabah. Photo: A. Lamb.