Variation within the *Hoya parasitica* (Asclepiadaceae) Complex in Thailand

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Hoya parasitica sensu lato is a climbing epiphyte belonging to the family Asclepiadaceae. At present, the taxonomic status of this species in Thailand is still dubious due to the great variability in size, shape and color of leaves and flowers. Morphological variation was investigated in 500 fresh plants collected from 50 sites throughout the country. The collected specimens represented the *H. parasitica* complex, including two polymorphic species, i.e., *H. parasitica* sensu lato and the closely related species *H. rigida* Kerr. Based on qualitative macro- and micro-morphological characters, the *H. parasitica* complex can be divided into nine groups. They can be distinguished by leaf shape, leaf base, venation pattern, leaf indumentum, and shapes of sepals, corona and corpusculum. Group I matched with the characteristics of *H. rigida* Kerr which has ovate leaves with a cordate base, 3-5 prominent nerves running from base to apex, indumentum absent on the abaxial surface, and lanceolate sepals. In contrast, group II is an unidentified taxon which is close to *H. parasitica* var. *citrina* (Ridl.) Rintz. It is charaterized by broad ovate leaves with cordate bases, 3-5 prominent nerves running from base to apex, and a narrowly oblanceolate-oblong corpusculum. Groups III and IV have distinctly different vegetative characters and do not correspond to the previously described varieties of *H. parasitica*. Their leaf venation is acrodromous, with 3 prominent nerves running from the leaf base parallel to the midrib and reaching the apex, but they are different in their shape of the leaf and coronal scale. Group III has ovate leaves with subcordate bases and elliptic coronal scales, while group IV has elliptic-oblong leaves with cuneate bases and ovate-lanceolate coronas. Groups V-IX are still of doubtful validity, having slight discontinuities in leaf shape, base and venation, and the shape of the coronal scale. They are treated in this paper as variable groups within *H. parasitica* var. *parasitica*.

Key words: *Hoya parasitica*, morphology, taxonomy, species complex

Introduction

Hoya parasitica (Roxb.) Wall. ex Wight (Asclepiadaceae) is one of the most common members of the section Euhoya (Hooker, 1883). It is relatively widespread, occuring from E. India-Assam through Myanmar, Thailand, Indo-China, Malay Peninsula, and Sumatra to N. Borneo (Rintz, 1978). The most recent taxonomic study of the species (Kiew, 1995), included three varieties: *H. parasitica* var. *parasitica*, *H. parasitica* var. *citrina* and *H. parasitica* var. *hendersonii.* These varieties can be distinguished from each other by leaf characters and habitat. In Thailand, *H. parasitica sensu lato* is the most common, and is an extremely variable species. There is variation in texture, shape, size and venation of leaves, the size of the flower and shape of corolla lobes (Kerr, 1951). These plants were later named "the *H. parasitica* complex" (Thaithong, 1995). However, variations within this complex did not match properly with the three fomerly recognized infraspecific taxa. Additional intensive research into relationships within this difficult group of plants has not been carried out for many years. Moreover, previously distinct species, *H. ridleyi* and *H. rigida*, have been taxonomically confused with *H. parasitica* sensu lato. *H. ridleyi* is found in peninsular Thailand (Ridley, 1923), but has also been recognized as *H. parasitica* var. *parasitica* (Rintz, 1978). Then, Veldkamp et al. (1995) suggested that *H. rigida*, a species endemic to Thailand, may be included in *H. parasitica* sensu lato. Thus, the taxonomic status of *H. parasitica* complex in Thailand is still doubtful and needs to be reinvestigated.

We hypothesize that the *H. parasitica* complex in Thailand is composed of several undescribed taxa. We have explored all the available variables in the complex and have determined macro- and micro-morphological variations of each group. In this paper, we have (1) described the overall qualitative morphological variation within characters in the complex, (2) classified the

variations into groups, and (3) described morphological characters, geographical distribution and ecological features of each recognized group. We then (4) discuss the taxonomic treatment of these recognized groups as compared with the previous classification.

Methodology

1. Plant Morphology

Plant materials used in this study were collected from 50 sites throughout Thailand during 2002-2003 (Table 1, Fig. 1) and all were raised in the same conditions in a greenhouse at the Department of Botany, Faculty of Science, Chulalongkorn University. Flower and leaf materials were then gathered from the living collection. These were preserved in 70% ethanol for further morphological studies. In general, the morphological characters of leaves and flowers were examined using light microscopy (LM). Leaf indumentum on both surfaces was observed under LM and scanning electron microscopy (SEM).

2. Habitat and Distribution

Habitats of the *H. parasitica* complex were studied and their location recorded using GPS. Collection sites were plotted on an outline map thus showing their distribution, in relation to forest types and elevation, and as characterizing the habitats of particular members of the complex.

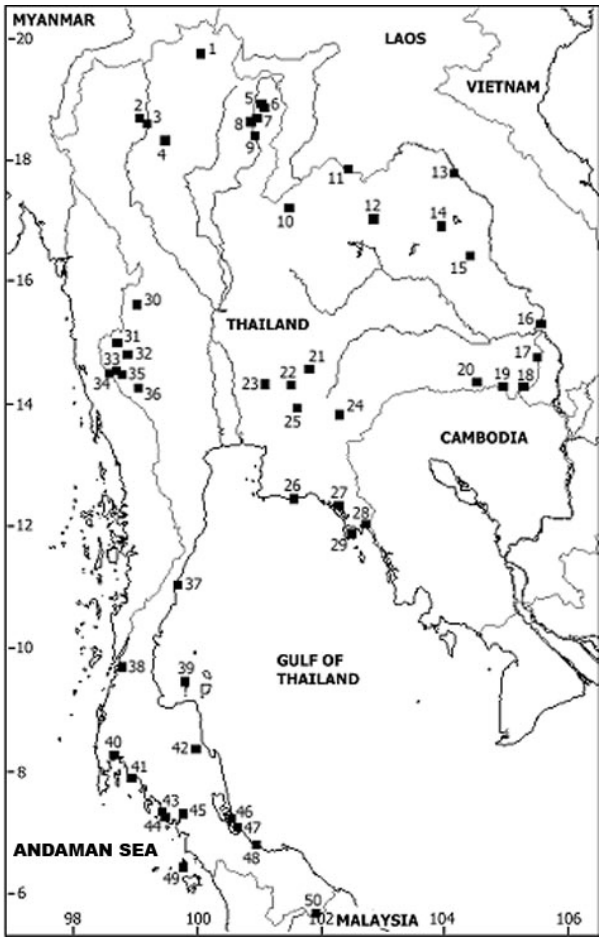

Figure 1. Sampling sites of *H. parasitica* complex in Thailand.

Table 1. Localities and collection-groups of the "*Hoya parasitica* complex" in Thailand

Site no.[a]	Locality	Group[b]
1.	Mueang, Chiang Rai Province	V
2.	Wang Bua Ban Waterfall, Chiang Mai Province	V, IX
3.	Haew Keaw, Mueang, Chiang Mai Province	VI
4.	Doi Khun Tan National Park, Lampang Province	IX
5.	Silaphet Waterfall, Pua, Nan Province	III, VII
6.	Tat Laung Waterfall, Pua, Nan Province	VII
7.	Ban Muang Wang Nhua, Phu Phiang, Nan Province	IX
8.	Phasing, Mueang, Nan Province	V
9.	Lhinan, Na Noi, Nan Province	VII, IX
10.	Pla Ba Waterfall, Phu Ruea, Loei Province	IX
11.	Than Thong Waterfall, Sri Chiang Mai, Nong Khai Province	IX
12.	Than Ngam Waterfall, Nong Wua So, Udon Thani Province	IX
13.	Tat Kham Waterfall, Ban Phaeng, Nakhon Phanom Province	IX

Table 1. (continued)

Site no.[a]	Locality	Group[b]
14.	Phu Phan National Park, Sakon Nakhon Province	IX
15.	Tat Ton Waterfall, Mukdahan Province	IX
16.	Soi Sawan Waterfall, Ubon Ratchathani Province	IX
17.	Huai Sai Yai Waterfall, Sirinthon, Ubon Ratchathani Province	IX
18.	Phu Chongna Yoi National Park, Ubon Ratchathani Province	IX
19.	Tat Hai Waterfall, Nam Yuen, Ubon Ratchathani Province	IX
20.	Sam Rong Kiat Waterfall, Khun Han, Si Sa Ket Province	IX
21.	Phu Wa Kiew Waterfall, Nakhon Ratchasima Province	IX
22.	Khao Yai National Park, Nakhon Ratchasima Province	I, IX
23.	Pu Kae, Saraburi Province	IX
24.	Pang Sida National Park, Sa Kaeo Province	IX
25.	Prachantakham, Prachin Buri Province	IX
26.	Ban Pe, Rayong Province	VIII
27.	Nam Tok Phliu National Park, Chanthaburi Province	VIII
28.	Mueang, Trat Province	VIII
29.	Ko Chang, Trat Province	VIII
30.	Thi Lo Su Waterfall, Tak Province	IX
31.	Sangkhla Buri, Kanchanaburi Province	IX
32.	Koeng Kra Wia Waterfall, Kanchanaburi Province	IX
33.	Pong Ron, Thong Pha Phum, Kanchanaburi Province	IX
34.	Pha Suk Pass,Thong Pha Phum, Kanchanaburi Province	I
35.	Ban Thamadua, Thong Pha Phum, Kanchanaburi Province	IX
36.	Sai Yok National Park, Kanchanaburi Province	IX
37.	Bang Saphan, Prachuap Khiri Khan Province	VIII
38.	Namtok Ngao National Park, Ranong Province	IX
39.	Ko Wua Ta Lub, Suratthani Province	VIII
40.	Mueang, Phangnga Province	VIII
41.	Noppharat Thara Beach, Krabi Province	VIII
42.	Khao Luang National Park, Nakhon Si Thammarat Province	I
43.	Pakmeng, Trang Province	VIII
44.	Hat Chao Mai National Park, Trang Province	VIII
45.	Thung Kai, Trang Province	VIII
46.	Sathing Phra, Songkhla Province	VIII
47.	Singhanakhon, Songkhla Province	VIII
48.	Pak Bang Sakom Beach, Songkhla Province	VIII
49.	Tarutao National Park, Satun Province	IV, VIII
50.	Sirinthon Waterfall, Waeng, Narathiwat Province	II

Note: a =Site numbers correspond to those in Fig. 1; b =Nine groups distinguished in this study.

Results

Despite the great observed variations (i.e., habitat, leaf shape, forms of leaf base, venation pattern of leaf, forms of sepal and corona), we can tentatively classify members of the complex into 9 groups by comparisons of qualitative morphological characters. These groups were then named as groups I-IX (IX being the residual group). Examples of leaves and flowers examined are shown in Fig. 2 - Fig. 6. A key to groups and descriptions of the groups are presented below.

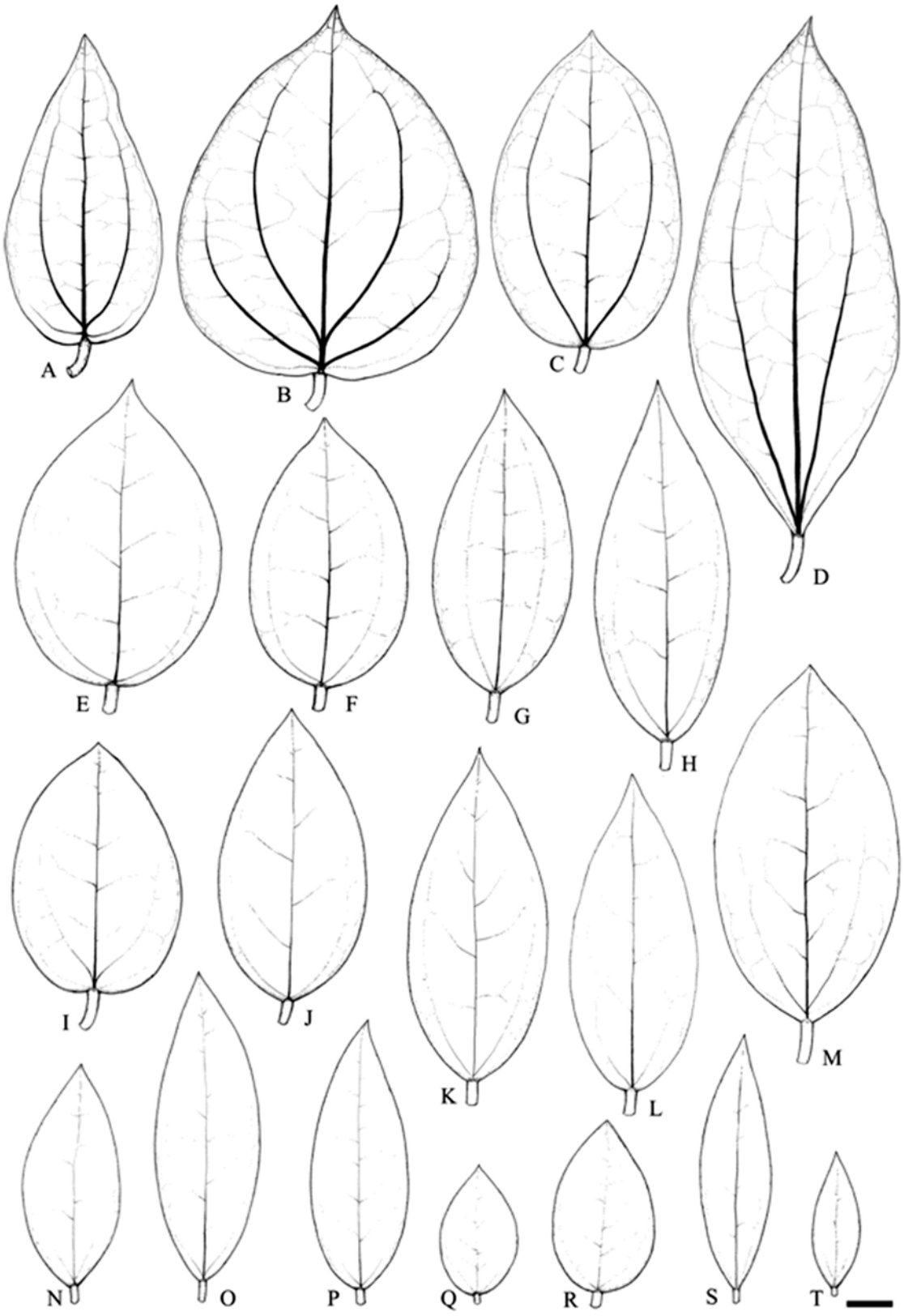

Figure 2. Leaves of the "*Hoya parasitica* complex". A: Group I (166). B: Group II (303). C: Group III (380). D: Group IV (320). E-F: Group V, E (404), F (378). G-H: Group VII, G (385), H (384). I: Group VI (289). J-M: Group IX, J (559), K (436), L (3), M (258). N-T: Group VIII, N (120), O (670), P (660), Q (585), R (243), S (213), T (202). Numbers in parentheses denote the collection number. Bar = 2 cm.

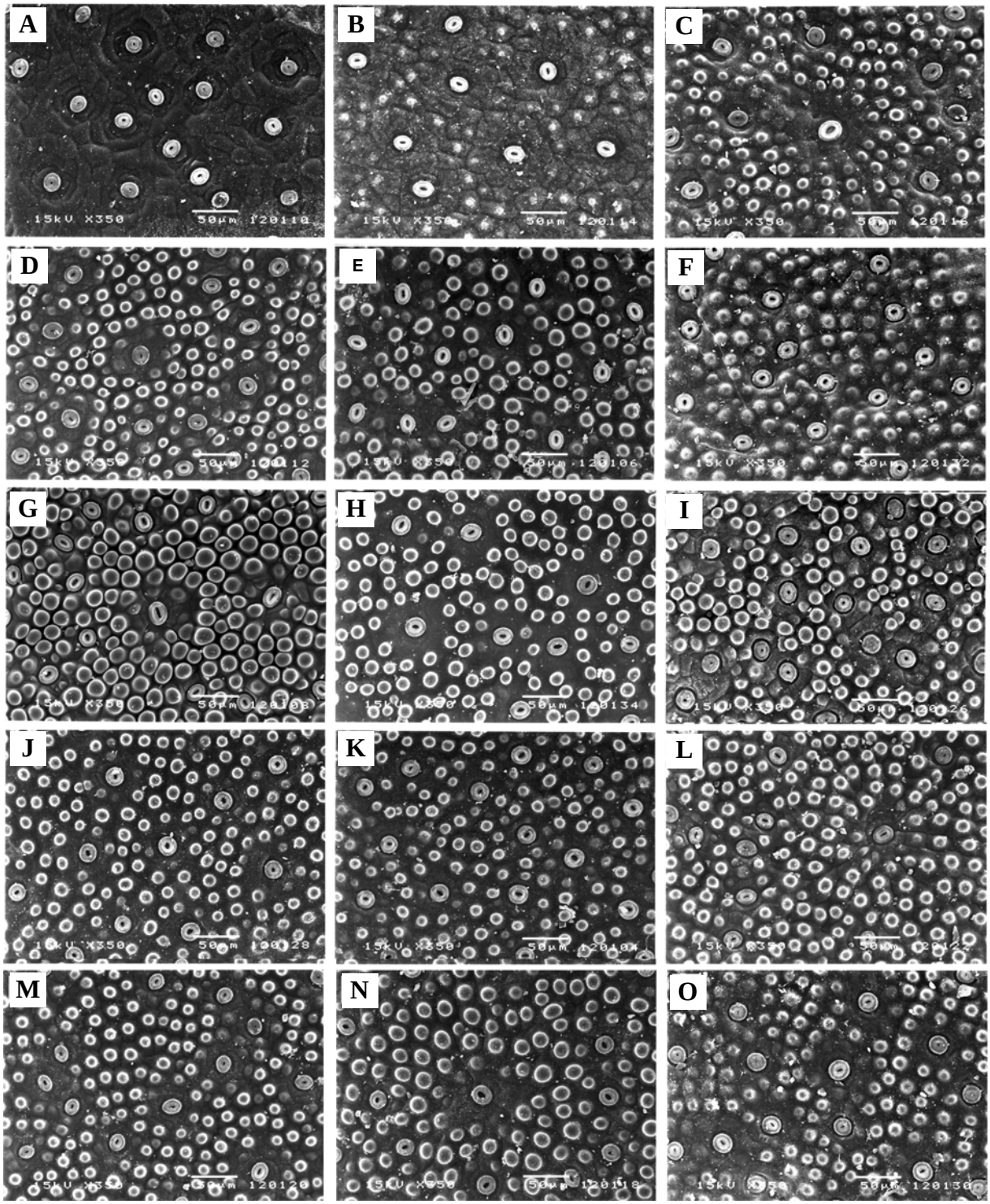

Figure 3. Scanning electron micrographs of abaxial surfaces of leaves of nine groups. A: Group I (166). B: Group II (303). C: Group III (380). D: Group IV (320). E-F: Group V, E (312), F (378). G: Group VI (289), H: Group VII (384). I-K: Group VIII, I (585), J (636), K (202). L-O: Group IX, L (429), M (3), N (508), O (258). Numbers in parentheses denote the collection number. Bar=50µm.

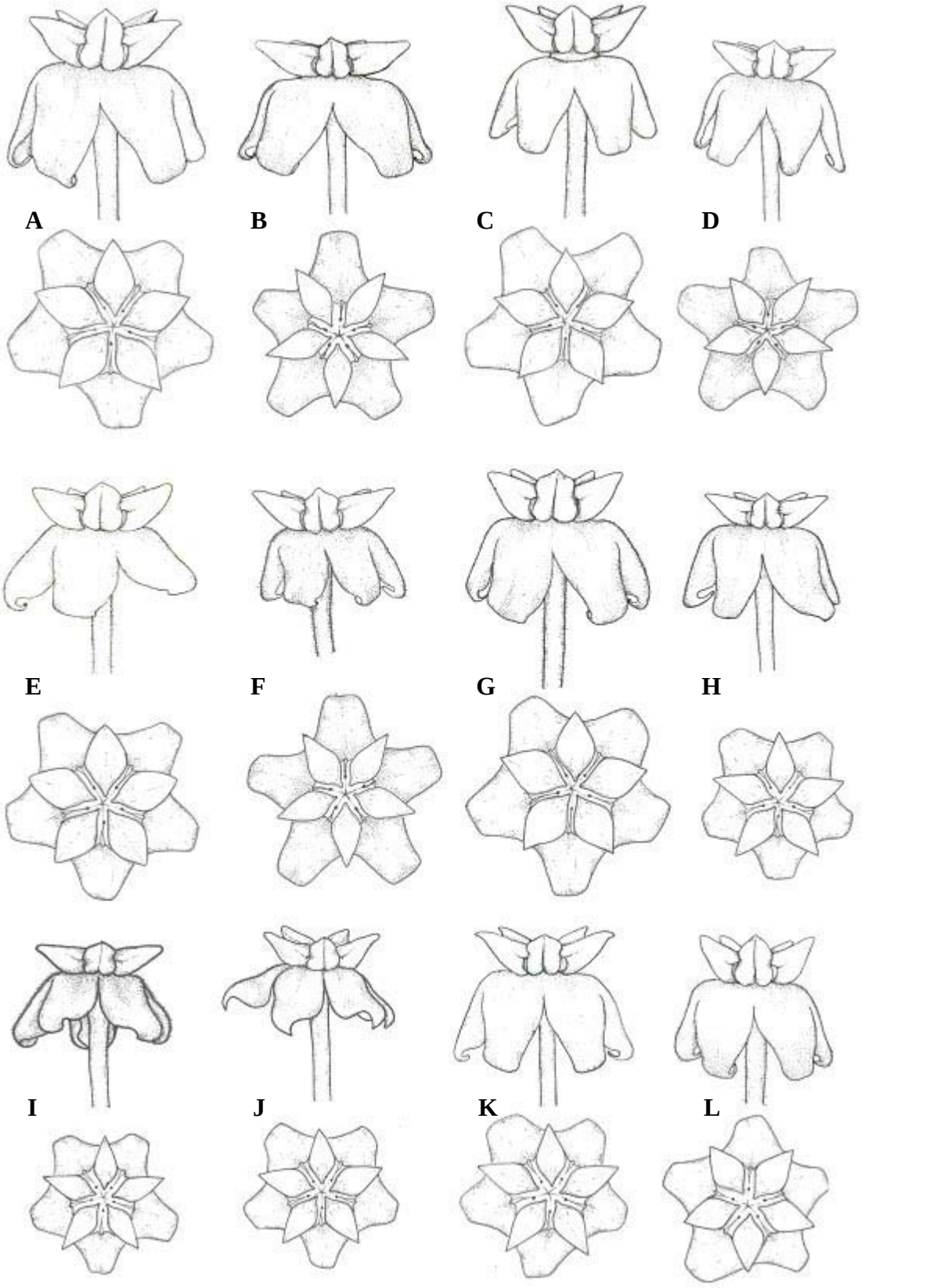

Figure 4. Flowers of the "*Hoya parasitica* complex" (lateral and top view). A: Group I (166). B: Group II (303). C: Group III (380). D: Group IV (320). E: Group V (404), F: Group VI (289), G: Group VII (364). H-I: Group VIII, H (660), I (202). J-L: Group IX, J (436), K (258) L (559). Numbers in parentheses denote the collection number. Bar=5 mm.

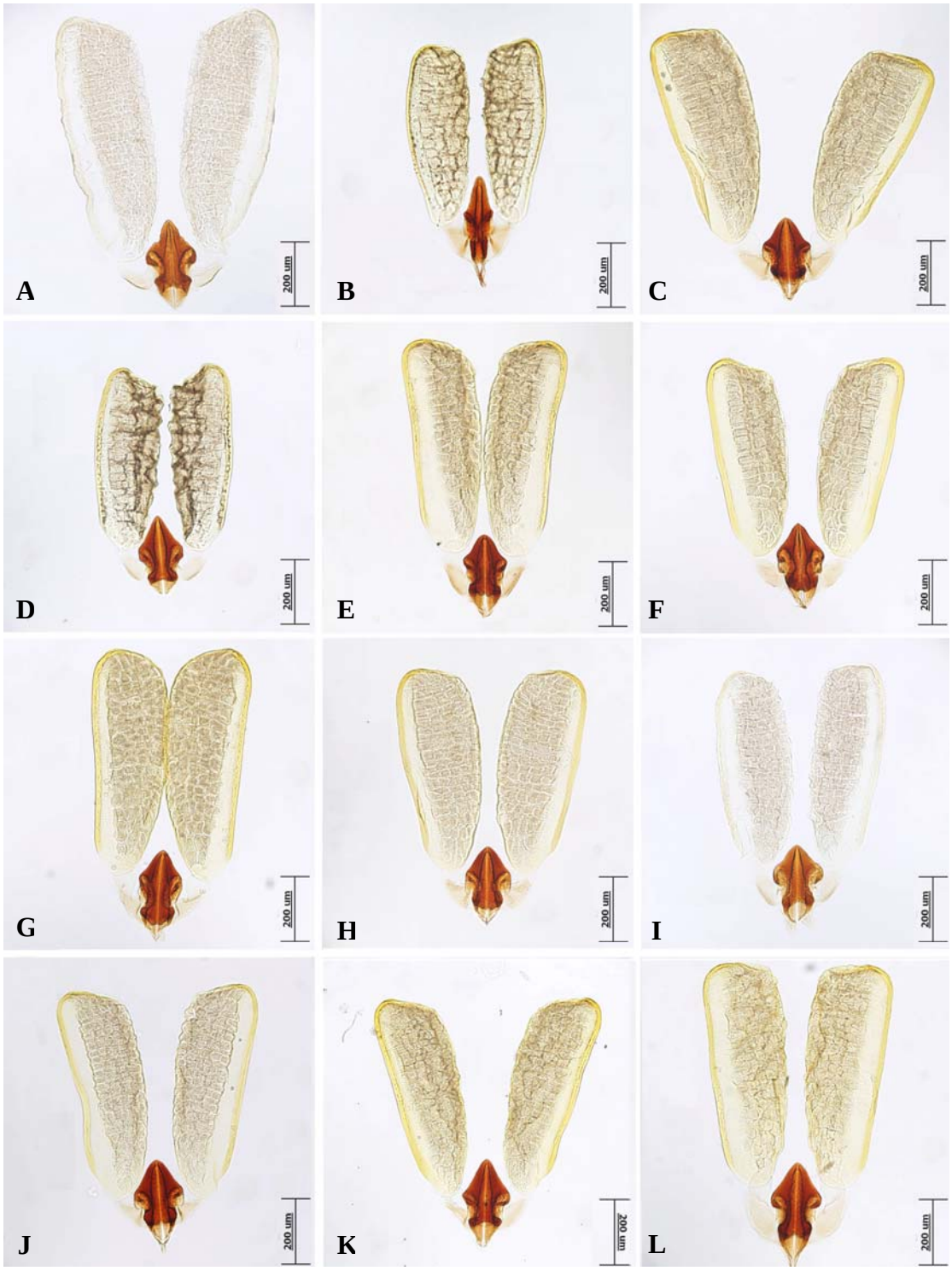

Figure 5. Twin-pollinia of the "*Hoya parasitica* complex". A: Group I (166). B: Group II (303). C: Group III (380). D: Group IV (320). E: Group V (404), F: Group VI (289), G: Group VII (384). H-I: Group VIII, H (660), I (202). J-L: Group IX, J (436), K (258), L (559). Numbers in parentheses denote the collection number. Bar= 200 µm.

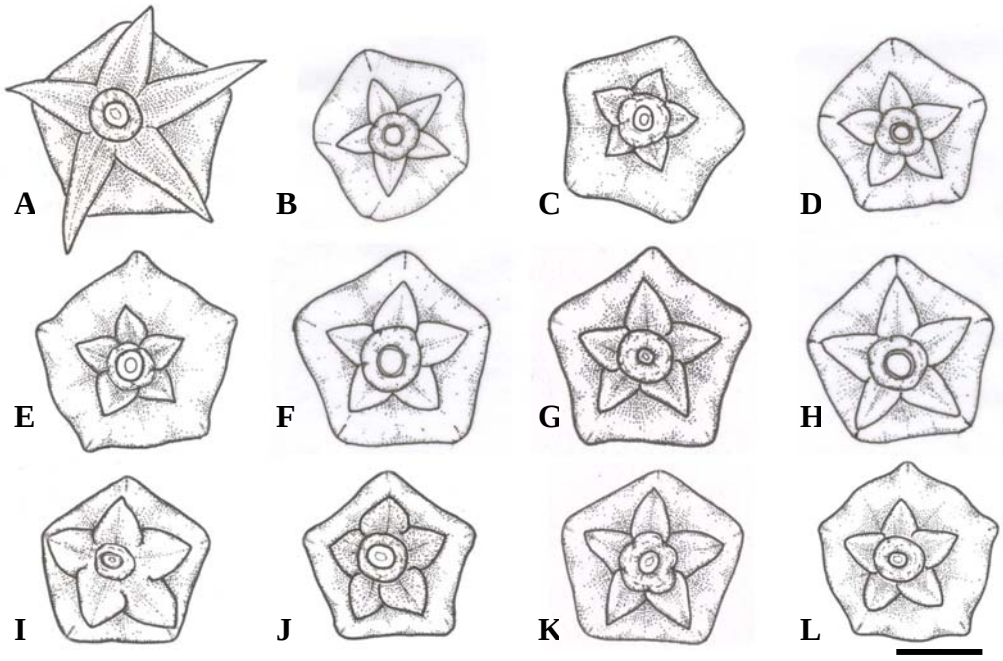

Figure 6. Flowers of the "*Hoya parasitica* complex" showing sepals (bottom view). A: Group I (166). B: Group II (303). C: Group III (380). D: Group IV (320). E: Group V (404), F: Group VI (289), G: Group VII (384). H-I: Group VIII, H (660), I (202). J-L: Group IX, J (436), K (258) L (559). Numbers in parentheses denote the collection number. Bar=5 mm.

Key to groups of wild *H. parasitica* complex in Thailand

1. Sepals lanceolate, longer than the corolla tubes; leaves glabrous ..... **Group I**
1. Sepals ovate, equal in length or shorter than corolla tubes; leaves papillate on abaxial surface
    2. Leaves with prominent basal nerves, extending from base to apex, veins conspicuous
        3. Leaves ovate, base rounded to cordate
            4. Coronal scales ovate-lanceolate, corpusculum narrowly oblanceolate-oblong ..... **Group II**
            4. Coronal scales ovate-elliptic, corpusculum broadly triangular-oblong ..... **Group III**
        3. Leaves ovate-oblong, base cuneate ..... **Group IV**
    2. Leaves with unclear basal nerves, mostly extending about half way to apex, veins obscure
        5. Leaf base rounded to subcordate
            6. Coronal scales ovate-elliptic, petioles stout ..... **Group V**
            6. Coronal scales ovate-lanceolate, petioles slender ..... **Group VI**
        5. Leaf base cuneate to obtuse
            7. Coronal scales ovate-elliptic ..... **Group VII**
            7. Coronal scales ovate-lanceolate
                8. Leaves relatively narrow, 1.8-(3.8)-5.8 cm wide, base cuneate. Littoral plants ..... **Group VIII**
                8. Leaves broad, 4-(5.8)-8.6 cm wide, base variable. Inland plant ..... **Group IX**

Discussion and Conclusions

Hoya parasitica has long been recognized as a taxonomically confusing group of the genus *Hoya*. Many authors have differently discerned taxa within the complex. The confusion was partly due to the great variation exhibited by the plants in their natural habitats. The results from this present

study indicate that nine morphological groups can be recognized based on leaf shape, form of leaf base, leaf venation, leaf indumentum, shape of sepal, and shape of corona scale. However, the *Hoya parasitica* specimens could not be consistently allocated into discrete groups based on lamina texture, color of flower and hair. Lamina texture was found to be a slightly discontinuous variable. This variation appeared to be related to growing conditions in different habitats (Hill, 1988). Color of flowers has been reported to be highly variable in this species (Kiew, 1995). In this study, we found that the color of the corolla varied from white, creamy white, yellowish white, greenish white, pinkish white to white with brown, pink and violet at the apices. Hair was frequently found on the stem, corolla (adaxial surface), calyx (abaxial surface) and pedicel. Young stems and new branches varied from glabrous to pubescent, or earlier pubescent then becoming glabrous when getting old, but some plants were consistently glabrous. Hair on the pedicel also varied from glabrous to densely pubescent. In contrast, in some populations hairiness varied from glabrous to densely pubescent, while in others hairiness was only glabrous or pubescent. Hair on the corolla varied from minutely pubescent (almost glabrous to the naked eye) to densely pubescent (obvious to the naked eye). All the above characters (lamina texture, color of flower and hair) possess sufficient variability for us to conclude that they are not good discriminant characters for distingishing taxa of this complex.

Regarding habitats and distributions, the 9 recognized groups of the complex occur in different floristic regions and habitats throughout the country. It was found that groups I, II and IV occur in rather humid forests with medium to low light conditions, while the other groups usually grow in dry habitat to some extent. These differences are possibly related in part to the degree of succulence and size of leaves that allow plants to withstand different light conditions (Forster and Liddle, 1991). Naturally, the members of the complex occur in a wide range of habitats and geographic features in Thailand. Anyway, the habitat and distribution of the 9 groups overlap to such a degree that they are not good characters to use to distinguish taxa in the complex.

The previous treatments of the genus *Hoya* and the *Hoya parasitica* complex, were based primarily on discrete characters of floral structures (Hooker, 1883; Rintz, 1978; Forster and Liddle, 1991; Kiew, 1995). In this study, we used floral characters in defining the species, while vegetative characters and their geographical distribution were used to specify the varieties. Hence, we considered that the nine groups in the *H. parasitica* complex are best treated as species and varieties. Group I and group II of the *H. parasitica* complex were treated at species level, due to their discontinuity in floral and vegetative characters.

Group I corresponds to the previously described species, *Hoya rigida* Kerr (Kerr, 1939). The result from this study shows good diagnostic characters to recognize this species based on leaf shape, venation, sepal shape and ratio of corolla tube length to sepal length. We agreed with Kerr (1939) to separate this species from *H. parasitica* s.l., and eliminated the suspicion by Veldkamp *et al*. that this species should be included in *H. parasitica* s.l.

Group II is somewhat similar to *H. parasitica* var. *critina* (Ridl.) Rintz except for its retention of minute hairs, scattered over the abaxial surface. Furthermore the corpusculum of anthers are oblanceolate-oblong. Rintz (1978) describes leaves and flowers of *H. parasitica* var. *citrina* and his illustrations show that the lower surfaces of leaves have distinctly dense hairs and triangular-oblong corpusculum. The result from this study indicated that group II is clearly distinguished from the *H. parasitica* s. l. Importantly, since it has some diagnostic characters (leaf broad ovate with cordate base; prominent, 3-5 nerves, extending from base to apex, hairs minute, scattered on the abaxial surface; corpusculum oblanceolate-oblong) which did not match any previously described taxa, we consider it should be treated as a new species. In addition, the fragrance of flowers in group II tends to differ from the other groups. We consider that this preliminary evidence suggests a chemical difference that may be used to recognize group II. At present, we treat group II as a cryptic and undescribed species within the *Hoya parasitica* complex.

Groups III and group IV have conspicuously discrete vegetative characters. Thus, we define them at the varietal level. Group III is similar to *H. parasitica* var. *citrina.* They share some common characters; possession of ovate leaves, the basal main veins extending to apex and the other veins being conspicuous, but there are still some differences. Group III has elliptic coronal scales and occurs in the lowlands of northern Thailand, while *H. parasitica* var. *citrina* has ovate-lanceolate coronal scales and occurs in Malaysia, being common on limestone hills. Group IV is an intermediate form

between *H. parasitica* var. *citrina* and *H. parasitica* var. *parasitica*. It shares its venation pattern with the variety *citrina*, while leaf shape is elliptic-oblong with cuneate base, this character is similar to the variety *parasitica*. It is evident that group III and group IV do not correspond to the previously described varieties. So we suggest that these two groups are new varieties of *H. parasitica* complex and treat them as undescribed taxa. However, these taxa are rather rare, each being found only at one site.

Groups V-IX have some discontinuity in flower and leaf characters. They can not be clearly distinguished into distinct species or varieties. Plants of groups VIII and IX correspond to the previous infraspecific taxon, *H. parasitica* var. *parasitica*. This is characterized by possession of an elliptic leaf shape, cuneate base, obscure veins and the lowest basal pair of main veins extending about halfway to the apex, while the other groups do not best fit this taxon. They have a broad ovate or elliptic to oblong leaf shape, obtuse to rounded at the base and are variable in corona lobe shape. However, they are more comparable to var. *parasitica* than are the other two previously described varieties, i.e. *H. parasitica* var. *citrina* and var. *hendersonii*, which have ovate leaves, a cordate base, 3 prominent nerves extending from base to apex and the other veins are also conspicuous. So we have treated groups V-IX as being variable forms of *H. parasitica* var. *parasitica*.

In conclusion, the proposed cryptic new species and new varieties of the *Hoya parasitica* complex in Thailand need to be researched further and definitive taxonomic conclusions reached. Such study is not part of this paper.

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