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Research Article

Phenetic Study of *Tabernaemontana divaricata* (L.) R.Br. ex Roem. & Schult. in Thailand

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ABSTRACT

Pinwheel Jasmine (*Tabernaemontana divaricata* L.; Apocynaceae) is widely distributed across South Asia, Thailand, and southern China and exhibits substantial morphological variation. This variability has resulted in persistent taxonomic confusion, particularly in Thailand, where distinguishing among phenotypic forms and related taxa remains challenging. Accurate taxonomic delimitation is essential for botanical classification, horticultural applications, conservation, and the reliable identification of plant resources. This study examined the taxonomic status of Pinwheel Jasmine in Thailand using numerical taxonomic approaches, including cluster and discriminant analyses. A total of 40 morphological characters (20 quantitative and 20 qualitative) were assessed across 210 operational taxonomic units (OTUs) representing seven phenotypes. Both analyses consistently resolved the OTUs into two distinct groups: (1) T. divaricata 'Ceylon Jasmine' (Phud Supachok) and (2) other Pinwheel Jasmine forms. Five quantitative characters were identified as the most diagnostic: lamina length (LML), lamina width (LMW), corolla lobe length (CLL), distance from the corolla tube base to stamen attachment (DCS), and style length (STL). These traits exhibited exceptionally high F-values in K-means cluster analysis (404.11, 432.90, 327.54, 530.04, and 181.02, respectively; $p<0.01$), indicating strong discriminatory power. The results demonstrate that Phud Supachok is consistently and clearly morphologically distinct from other Pinwheel Jasmine forms. However, because this study is based solely on phenetic data, additional molecular evidence is required before definitive taxonomic conclusions can be made. Integrative studies combining molecular and morphological data are recommended to refine species delimitation within Tabernaemontana.

1. Introduction

Tabernaemontana divaricata (L.) R.Br. ex Roem. & Schult. (Apocynaceae), commonly known as Pinwheel Jasmine or Ceylon Jasmine, was first published in 1819 (Roemer & Schultes 1819). This species is a perennial evergreen shrub native to South Asia, with its distribution extending to Thailand, southern China, and other tropical regions of Southeast Asia. It is widely cultivated as an ornamental plant due to its attractive white flowers and glossy green foliage (Ghosh *et al.* 2021). The stems of this species exude a milky latex when broken, earning it the local name "milk flower". *T. divaricata* has also been historically recognized under synonyms such as *T. citrifolia, T. coronaria*, and *Nerium coronarium* (Jena 2019).

The species is valued not only for its analgesic and antidiarrheal effects but also for its reported benefits as a tonic for the liver, spleen, and brain. Extracts of *T. divaricata* have demonstrated antioxidant, anti-inflammatory, and reversible acetylcholinesterase inhibitory activities. Morphologically, the species

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shows extensive variability in flower shape and size, leaf form and dimensions, plant height, and fruit characteristics, resulting in substantial diversity at the species and infraspecific levels. Furthermore, the plant is a rich source of biologically active alkaloids, including tabernaemontanine, coronaridine, dregamine, and voacangine, which are present in roots, stems, bark, leaves, and flowers. Some of these compounds have been reported to exhibit medicinal properties such as anticancer activity in dried flowers, as well as therapeutic uses in traditional Ayurvedic medicine (Gopinath *et al.* 2011; Raj & Balasubramaniam 2011; Pushpa *et al.* 2012; Poornima *et al.* 2012; Das *et al.* 2022).

In Thailand's ornamental plant market, seven distinct phenotypes of Pinwheel Jasmine are commonly recognized (Figure 1A-F). However, when identified using the morphological keys in the Flora of Thailand (Forest Herbarium 2025), all forms are referred to as a single species, *T. divaricata*. The name even appears multiple times in the key (Figure 2), reflecting the

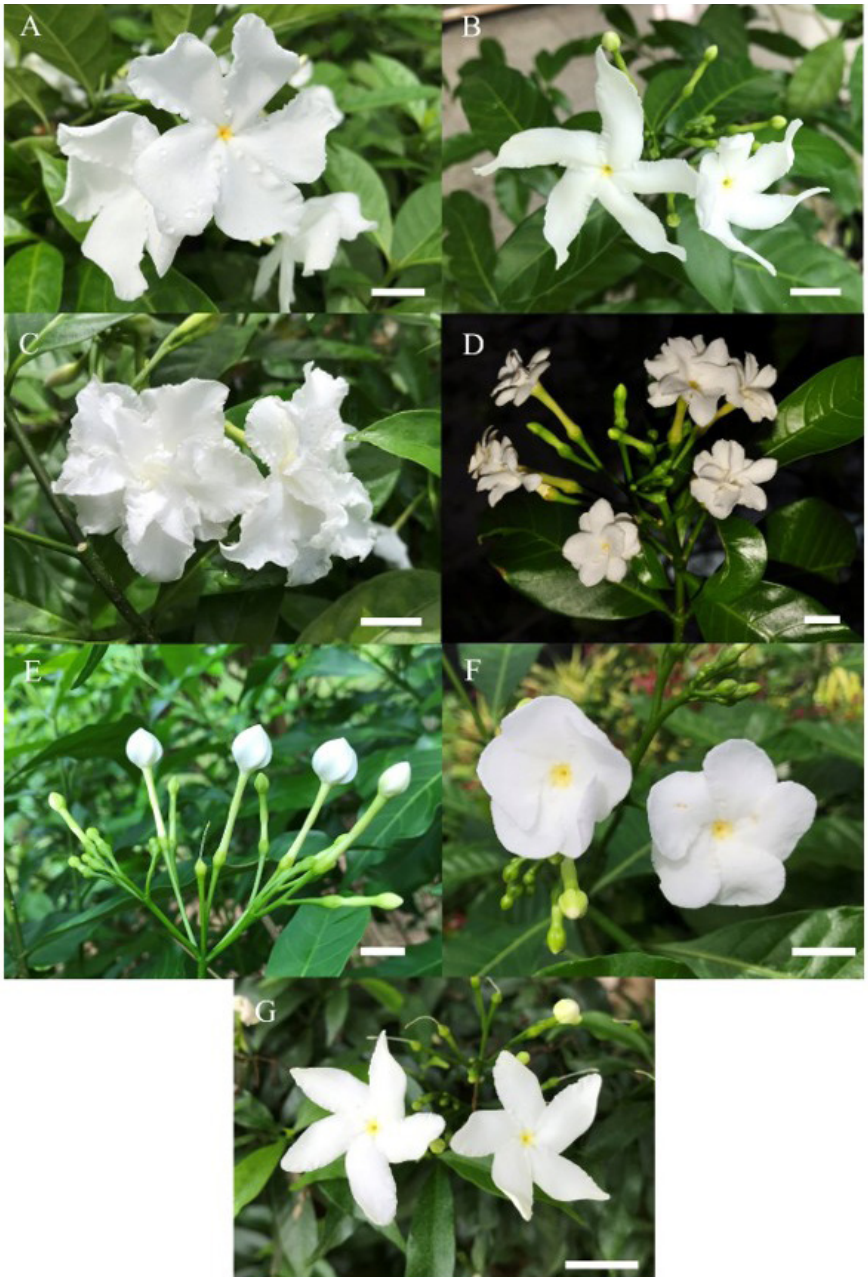

Figure 1. Variation in floral characteristics of *T. divaricata*. (A) Phud Suan, (B) Phud Kung Hun, (C) Phud Kulap, (D) Phud Son, (E) Phud Malai, (F) Phud Saeng Chan, (G) Phud Supachok. Scale bar = 1 cm

extremely high morphological variation and highlighting the ongoing taxonomic debate regarding the precise status of these phenotypes in Thailand.

From the preliminary study, 18 dried specimens of *T. divaricata* preserved at the Forest Herbarium (BKF) were found, collected from various times and regions across Thailand. Most specimens exhibited inflorescences with flowers that opened before falling, single-layered petals, rounded corolla-lobe tips, and acuminate leaf apices. However, this research found variation in inflorescence length, flower-bud size, corolla lobes, and corolla tubes, as well as in leaf size and shape (Figure 3). These variations suggest that *T. divaricata* may represent a species complex, due to the diversity observed in floral characteristics, which are reproductive traits. This finding is consistent with studies in other flowering plant families, such as Fabaceae, Phrymaceae, and Zingiberaceae, in which species complexes often

KEY TO THE SPECIES

1A. Corolla double, plant cultivated ..... 4. *T. divaricata*
1B. Corolla single ..... 2.

2A. Leaf blade coriaceous when dry, usually obtuse or rounded at the apex, rarely shortly acuminate; sepals not much longer than wide ..... 5. *T. macrocarpa*
2B. Leaf blade papery or subcoriaceous when dry, usually acuminate or caudate at the apex; sepal ratio variable ..... 3.
3A. Sepals not ciliate, 5–9 mm long, leafy and often cordate, or linear ..... 9. *T. rostrata*
3B. Sepals minutely ciliate or not, 0.9–7 mm long, those more than 5 mm long not linear or leafy ..... 4.
4A. Corolla lobes minutely ciliate, at least in lower half; flower robust; sepals ciliate ..... 3. *T. corymbosa*
4B. Corolla lobes not ciliate; flower robust or slender; sepals ciliate or not ..... 5.

5A. Sepals rounded or obtuse; corolla tube not twisted; stamens inserted in lower third of corolla tube ..... 4. *T. divaricata*
5B. Sepals acute, acuminate or obtuse; corolla tube twisted or not; stamens inserted around middle or in upper half of corolla tube ..... 6.

6A. Head of mature corolla bud rounded or obtuse; sepals minutely ciliate or not ..... 7.
6B. Head of mature corolla bud acute or acuminate; sepals usually not ciliate ..... 9.

7A. Leaves glabrous or pubescent; corolla tube glabrous inside; flowers weakly or not scented; fruits with ridges ..... 6. *T. pandacaqui*
7B. Leaves glabrous; corolla tube normally pubescent around stamen insertion; flowers fragrant; fruits without ridges ..... 8.

8A. Corolla tube often twisted; head of mature corolla bud 0.2–0.3 of bud length; fruit 2.1–2.6 cm long, 1–3 seeded ..... 1. *T. bovina*
8B. Corolla tube not twisted; head of mature corolla bud 0.14–0.21 of bud length; fruit 0.7–1.9 mm long, 1–2 seeded8. ..... *T. peduncularis*

9A. Peduncle robust; corolla in mature bud 2.1–3 cm long ..... 4. *T. divaricata*
9B. Peduncle slender; corolia in mature bud 0.7–2.4 cm long ..... 10.

10A. Fruit with ridges, not torulose; sepals 2–8 x as long as broad; corolla bud mostly acuminate; leaves acuminate or caudate. ..... 7. *T. pauciflora*
10B. Fruit not ridged, torulose; sepals 1.5–3 x as long as broad; corolla bud mostly acute; leaves acuminate ..... 2. *T. bufalina*

Figure 2. Identification key of genus *Tabernaemontana* L. in Thailand. (edit from Forest Herbarium 2025)

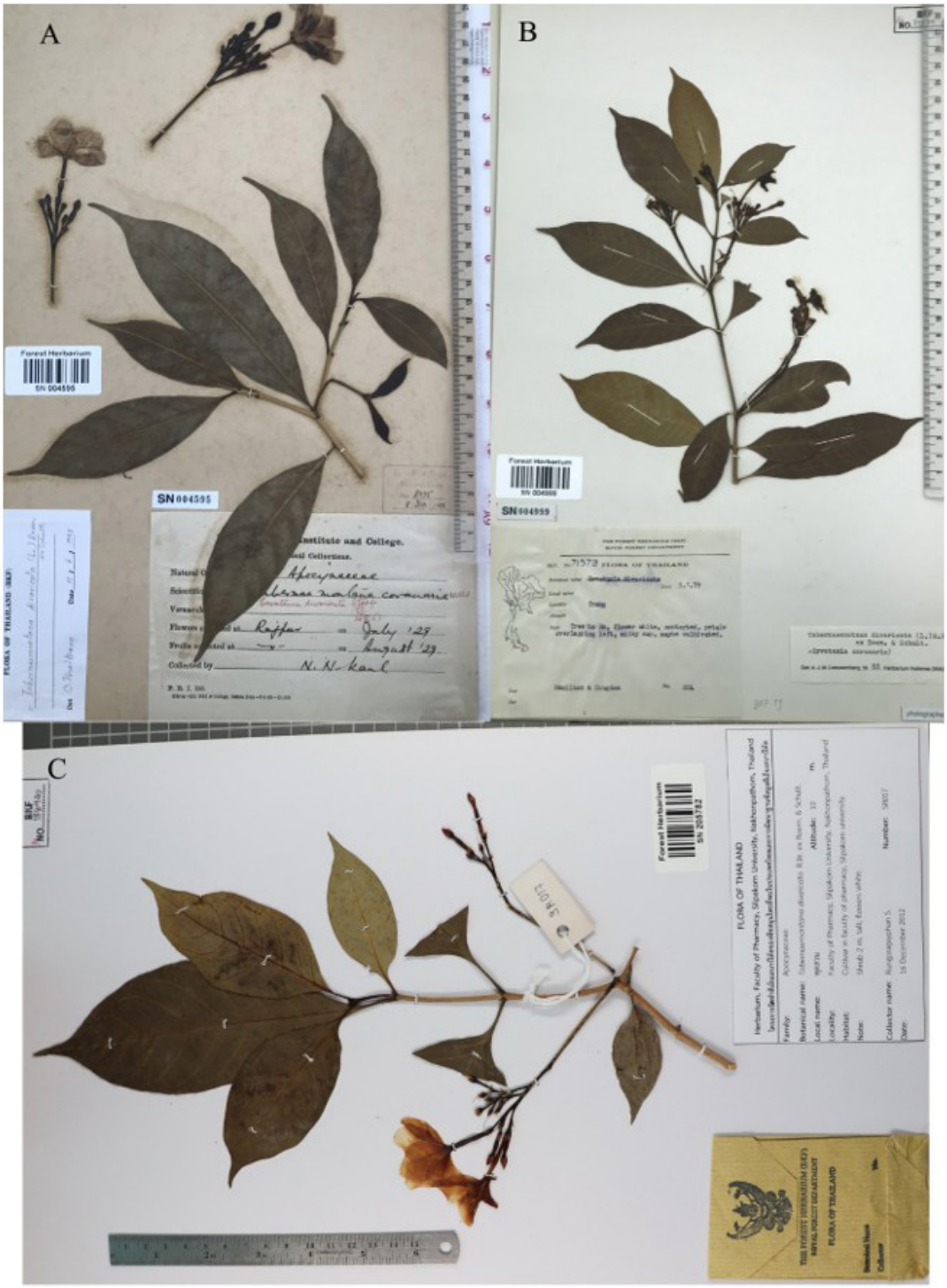

Figure 3. Herbarium specimen of *T. divaricata* in Thailand made by some collectors: (A) N.N. Kaul s.n, (B) Hamilton & Congdon no.204, and (C) S. Rungpragayphan no.SR017

exhibit high variation in floral morphology, making species delimitation difficult (Yuan 2019; Saryan *et al.* 2020; Nascimento *et al.* 2025).

Accurate identification of cultivars is further complicated by the limited variation in vegetative characters compared with flower morphology, making pre-flowering identification difficult. To address these challenges, the present study evaluates the taxonomic status of cultivated forms of *T. divaricata* available in the Thai ornamental plant market. Seven phenotypic variants were examined using numerical taxonomic methods, including cluster and discriminant

analyses, based on both reproductive and vegetative morphological characters. These methods are widely accepted for reducing subjectivity in delimiting taxa and for producing robust, reproducible results in taxonomic studies (Abdel–Hameed *et al.* 2015; Mapaya & Cron 2016; Tungmunnithum *et al.* 2017; Chen *et al.* 2018; Nair *et al.* 2021; Nurmawati 2024; Nurzaman *et al.* 2024; Rifqi & Chasani 2024; Vanitha & Selvi 2024).

2. Materials and Methods

2.1. Study of Herbarium Specimens

Morphological characteristics of *T. divaricata* were examined from dried specimens deposited at the Forest Herbarium (BKF), Department of National Parks, Wildlife and Plant Conservation, Thailand. The examination focused on reproductive and vegetative traits, including flower structure, corolla morphology, and leaf characteristics, to provide a comparative basis for living samples.

2.2. Specimen Collections

Field explorations and sample collections of *T. divaricata* and its cultivated varieties were conducted from October 2024 to February 2025. Samples were obtained from several ornamental plant markets in three provinces (Ratchaburi, Nonthaburi, and Bangkok) and from cultivation sites in five provinces (Chiang Mai, Khon Kaen, Nakhon Pathom, Trang, and Surat Thani). These locations represent diverse geographic and climatic regions, ensuring broad morphological variation among populations. Both plants sourced from ornamental markets and specimens deposited at the Forest Herbarium (BKF) were included in the morphometric analyses.

2.3. Preliminary Grouping and Definition of Taxonomic Units

All specimens were initially classified into Candidate Taxonomic Units (CTUs) based on observable morphological traits, such as leaf shape and calyx and corolla form. Each CTU was required to contain at least 30 OTUs, resulting in seven CTUs or phenotypic groups to ensure sufficient representation for statistical analysis. In total, 210 OTUs were examined.

2.4. Morphological Characterization and Measurement

Each OTU was examined for both quantitative (Nos. 1–20) and qualitative (Nos. 21–40) morphological traits. A total of 40 characters (Figure 4, Table 1) were assessed, encompassing vegetative traits (e.g., leaf length, leaf width, petiole length) and floral traits (e.g., bud size, corolla tube length, petal lobe width). Measurements were taken using a Mitutoyo digital micrometer (model CD-10APX) under a stereo microscope to ensure precision. All data were recorded systematically for statistical analysis.

2.5. Statistical Analysis

The recorded morphological data were subjected to Cluster Analysis to identify potential natural groupings among the specimens, with group support assessed using a 95% bootstrap value. Discriminant Analysis was used to validate group classifications at the 95% confidence interval. Both analyses were performed using SPSS software version 27. The results were interpreted to evaluate morphological variation and potential taxonomic distinctions among *T. divaricata* populations.

2.6. Preparation and Preservation of Reference Specimens

Representative dried specimens from each CTU were prepared as vouchers for this study. These specimens were deposited and curated at the Botany Laboratory, Department of Science and Bioscience Innovation, Faculty of Liberal Arts and Science, Kasetsart University, Kamphaeng Saen Campus, for future research and verification.

3. Results

3.1. Quantitative and Qualitative Characteristics of *T. divaricata*

From collections of *T. divaricata* and closely related ornamental forms, seven distinct morphotypes were identified based on observable morphological variation. These included P1 (‘Common Pinwheel Jasmine’, Phud Suan in Thai), P2 (‘Crape Jasmine’, Phud Kung Hun in Thai), P3 (‘Flore Pleno’, Phud Kulap in Thai), P4 (‘Double-Flowered Crepe Jasmine’, Phud Son in Thai), P5 (Phud Malai in Thai), P6 (‘Moon Beam Jasmine’, Phud Saeng Chan in Thai), and P7 (‘Ceylon Jasmine’, Phud Supachok in Thai); all belonging to *T. divaricata*. Each morphotype was studied both quantitatively and qualitatively in the Botany Laboratory using 30 OTUs per morphotype, yielding a total of 210 OTUs across the seven morphotypes. A total of 40 morphological characters were analyzed, encompassing both vegetative and reproductive traits (Table 2).

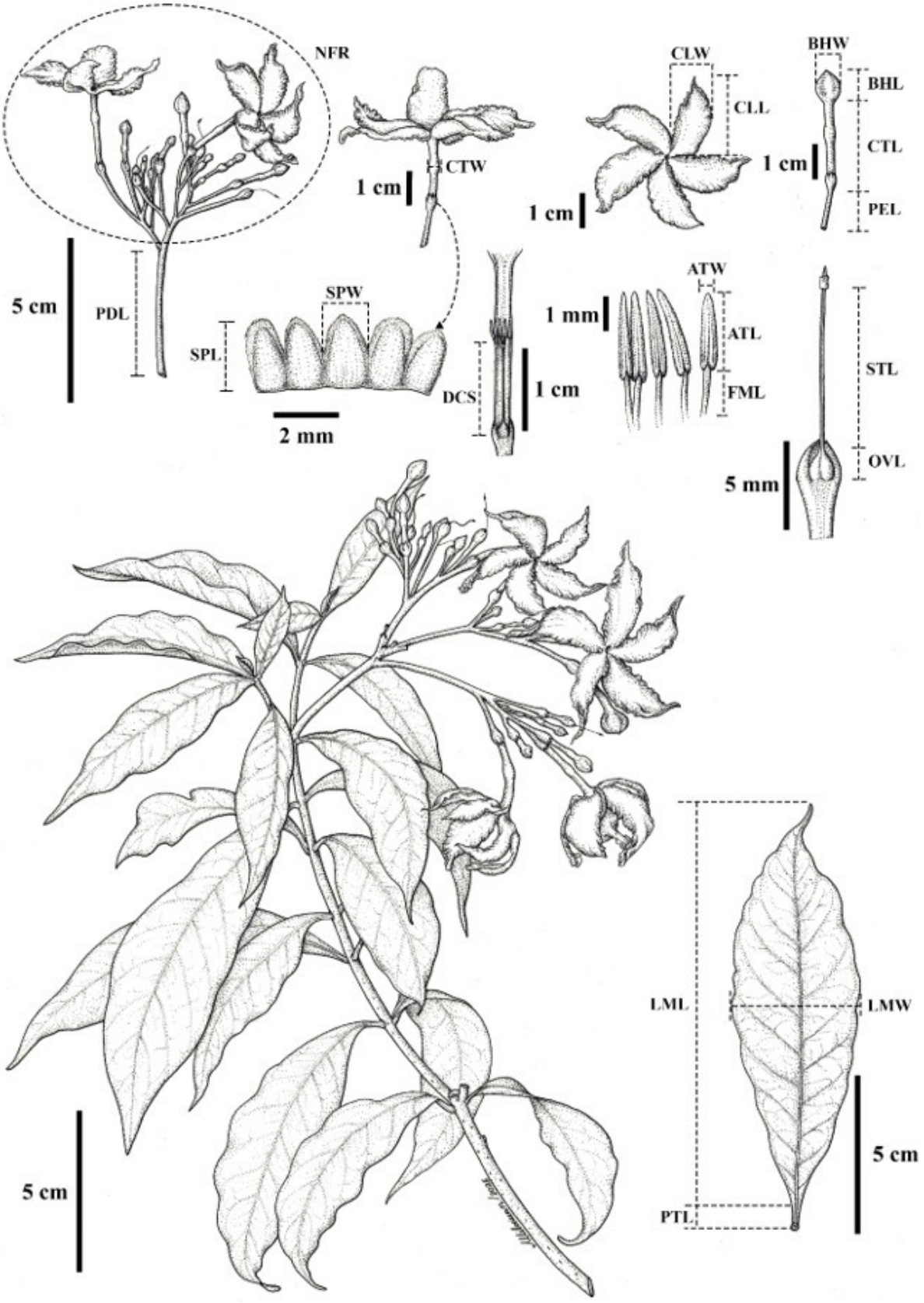

Figure 4. Measurement of a plant part

Table 1. List of quantitative (Nos. 1–20) and qualitative (Nos. 21–40) characters, their abbreviations, and full terms used in the character stage to distinguish the seven phenotypes of *T. divaricata* in Thailand

Abbreviation	Character stage
PLT	Petiole length (mm)
LML	Lamina length (mm)
LMW	Lamina width (mm)
PDL	Peduncle length (mm)
NFR	Number of florets per 1 inflorescence
PEL	Pedicel length (mm)
SPW	Sepal width (mm)
SPL	Sepal length (mm)
BHL	Bud head length (mm)
BHW	Bud head width (mm)
CTL	Corolla tube length (mm)
CTW	Corolla tube width (mm)
CLL	Corolla lobe length (mm)
CLW	Corolla lobe width (mm)
ATW	Anther's width (mm)
ATL	Anther's length (mm)
FML	Filament length (mm)
DCS	Distance between the base of the corolla tube and the attached stamen (mm)
OVL	Ovary length (mm)
STL	Style length (mm)
BRA	Branches: 1. Glabrous, 2. Lenticellate, 3. Sparsely pubescent
LTA	Leaves texture: 1. Papery, 2. Subcoriaceous
LSP	Leaf shape: 1. Elliptic, 2. Obovate
LAP	Leaves apex: 1. Acuminate, 2. Caudate
LBS	Leaves base: 1. Acute, 2. Cuneate, 3. Obtuse
LMG	Leaves margin: 1. More entire, 2. Slightly undulate, 3. More undulate
VEC	Vein color: 1. Same color as lamina, 2. Beneath paler than lamina
INF	Inflorescence: 1. Glabrous, 2. Sparsely pubescent
SPS	Sepal shape: 1. Ovate, 2. not Ovate
SPA	Sepal apex: 1. Acuminate, 2. Obtuse, 3. Round
SPM	Sepal margin: 1. Ciliate, 2. Not Ciliate
SPI	Sepal indumentum: 1. Glabrous, 2. Sparsely pubescent
CRL	Corolla: 1. Single, 2. Double
CMD	Corolla mature bud: 1. Globose head, 2. Ovoid head
CWF	Corolla when falling: 1. In bud, 2. Blooming
CRT	Corolla tube: 1. Twisted, 2. Not twisted
CTI	Corolla tube indumentum: 1. Glabrous outside and inside, 2. Sparsely pubescent inside
CLA	Corolla lobe apex: 1. Caudate, 2. Acute, 3. Obtuse to round
CLS	Corolla lobe shape: 1. Obovate, 2. Rounded, 3. Elliptic
STP	Stamens position: 1. bottom half or around the middle of the corolla tube, 2. upper half of the corolla tube

The comparative analysis revealed that these seven morphotypes differ notably in several key features. Qualitative traits, such as petal shape, corolla form, degree of petal twisting, and tip morphology, showed clear differentiation, particularly between single-flowered types (P1, P2, P5, P6, and P7) and double-flowered types (P3 and P4). P1 and P2 shared several common features—such as simple corollas, rounded or slightly pointed petal tips, and lanceolate leaves—characteristic of wild or less-modified forms. In contrast, P3 and P4 exhibited double-layered corollas with overlapping petals and larger floral diameters, typical of ornamental cultivars selected for aesthetic appeal.

Quantitative measurements revealed significant variation among the morphotypes. Traits such as leaf length and width, petiole length, bud length, corolla tube length, and corolla diameter varied widely across samples. For instance, P3 and P4 had the longest corolla tubes and the largest flower diameters, whereas P5, P6, and P7 exhibited intermediate floral sizes and distinctive petal curvature patterns. Leaf morphology also varied—P5 and P6 tended to have broader leaves, while P1 and P2 possessed narrower ones.

3.2. Cluster Analysis

Cluster analysis based on 40 quantitative and qualitative characters revealed that all 210 OTUs of *T. divaricata* were grouped into two main clusters (Figure 5). The first cluster consisted exclusively of all 30 OTUs of P7 (Phud Supachok). In contrast, the second cluster included the remaining 180 OTUs representing the other six morphotypes — P1 (Phud Suan), P2 (Sharp-petal Pinwheel), P3 (Phud Kulap), P4 (Phud Son), P5 (Phud Malai), and P6 (Phud Saeng Chan). The dendrogram clearly indicated that P7 (Phud Supachok) formed a distinct cluster, reflecting significant morphological divergence from the other morphotypes.

The five most discriminative characters contributing to this separation were all quantitative traits: leaf length (LML), leaf width (LMW), corolla lobe length (CLL), distance from leaf base to the attachment point of stamens on the corolla tube (DCS), and style length (STL). These traits exhibited the greatest variation across the examined samples and were the primary

Table 2. Means of 20 quantitative characters (Nos. 1-20) and comparison of 20 qualitative characters (Nos. 21-40) of the seven phenotypes of *T. divaricata* in Thailand

Character	P1	P2	P3	P4	P5	P6	P7
PLT	7.12	7.94	8.11	4.61	7.84	8.26	2.76
LML	149.13	146.93	103.63	111.90	132.50	122.37	35.19
LMW	66.23	44.23	46.87	49.13	39.73	52.23	9.30
PDL	36.47	43.46	22.29	9.24	31.19	56.40	10.06
NFR	13.93	12.93	1.87	6.33	16.83	16.47	20.53
PEL	5.28	15.41	13.86	6.24	16.36	7.61	7.28
SPW	1.40	1.08	1.80	1.13	0.99	2.08	0.85
SPL	3.70	1.81	3.49	2.49	2.04	3.89	1.95
BHW	4.70	4.44	7.07	5.20	4.81	6.37	2.56
BHL	8.59	6.91	15.46	14.43	8.68	11.55	4.06
CTL	12.69	22.55	28.21	8.52	21.93	21.67	17.51
CTW	2.45	1.57	4.04	3.11	1.62	2.91	1.41
CLW	13.58	7.27	15.53	10.49	6.67	13.10	4.82
CLL	22.74	19.21	17.06	18.97	17.43	21.31	10.26
ATW	0.35	0.64	0.87	0.64	0.65	0.88	0.55
ATL	2.87	2.59	3.13	2.59	2.70	3.13	2.01
FML	1.61	1.05	2.09	1.07	1.37	2.18	1.07
DCS	10.61	9.78	9.88	9.98	9.44	9.95	5.13
OVL	1.90	1.41	1.96	1.41	1.61	1.96	1.37
STL	10.15	9.04	10.05	9.04	9.07	10.05	6.67
BRA	2	2	2	2	2	2	2
LTA	1	1	2	1	2	2	2
LSP	2	2	1	2	2	1	1
LAP	2	2	2	2	2	2	2
LBS	1	1	1	2	1	1	1
LMG	1	3	2	2	3	2	2
VEC	2	2	2	2	2	2	2
INF	1	1	1	1	1	1	1
SPS	1	1	1	1	1	1	1
SPA	1	2	2	2	1	2	1
SPM	1	1	1	1	2	2	1
SPI	1	1	1	1	1	1	1
CRL	1	1	2	2	1	1	1
CMD	2	1	2	2	1	1	1
CWF	2	2	2	2	1	2	2
CRT	2	2	2	2	2	2	2
CTI	2	1	1	1	1	1	1
CLA	3	1	2	3	1	3	3
CLS	1	3	2	2	1	2	3
STP	2	1	1	1	1	1	1

Quantitative characters (Nos. 1–20) are measured in mm, while qualitative characters (Nos. 21–40) are coded according to the traits distinguishing the seven phenotypes of *T. divaricata* in Thailand (see Table 1). Character abbreviations are defined in Table 1

factors that separated P7 from the other morphotypes. Specifically, P7 showed significantly smaller leaf size, shorter corolla lobes, and reproductive structures, clearly distinguishing it within the *T. divaricata* complex (Table 3, Figure 6).

3.3. Discriminant Analysis

The discriminant analysis revealed that P7 (Phud Supachok) is the most distinct morphotype, consistent with the results of the cluster analysis. This distinction is primarily due to its clearly differentiated quantitative traits, which set it apart from the other six morphotypes. Within the larger group of the remaining six morphotypes, discriminant analysis further separated them into two subgroups (Figure 7), corroborating the patterns observed in the cluster analysis (Figure 5). Subgroup 1 included P5 (Phud Malai) and P2 (Sharp-petal Pinwheel), while Subgroup 2 comprised P6 (Phud Saeng Chan), P1 (Phud Suan), P4 (Phud Son), and P3 (Phud Kulap).

The differentiation of these subgroups appears to be driven primarily by qualitative floral traits. Larger flowers with rounded petal tips characterize Subgroup 2, whereas Subgroup 1 does not display

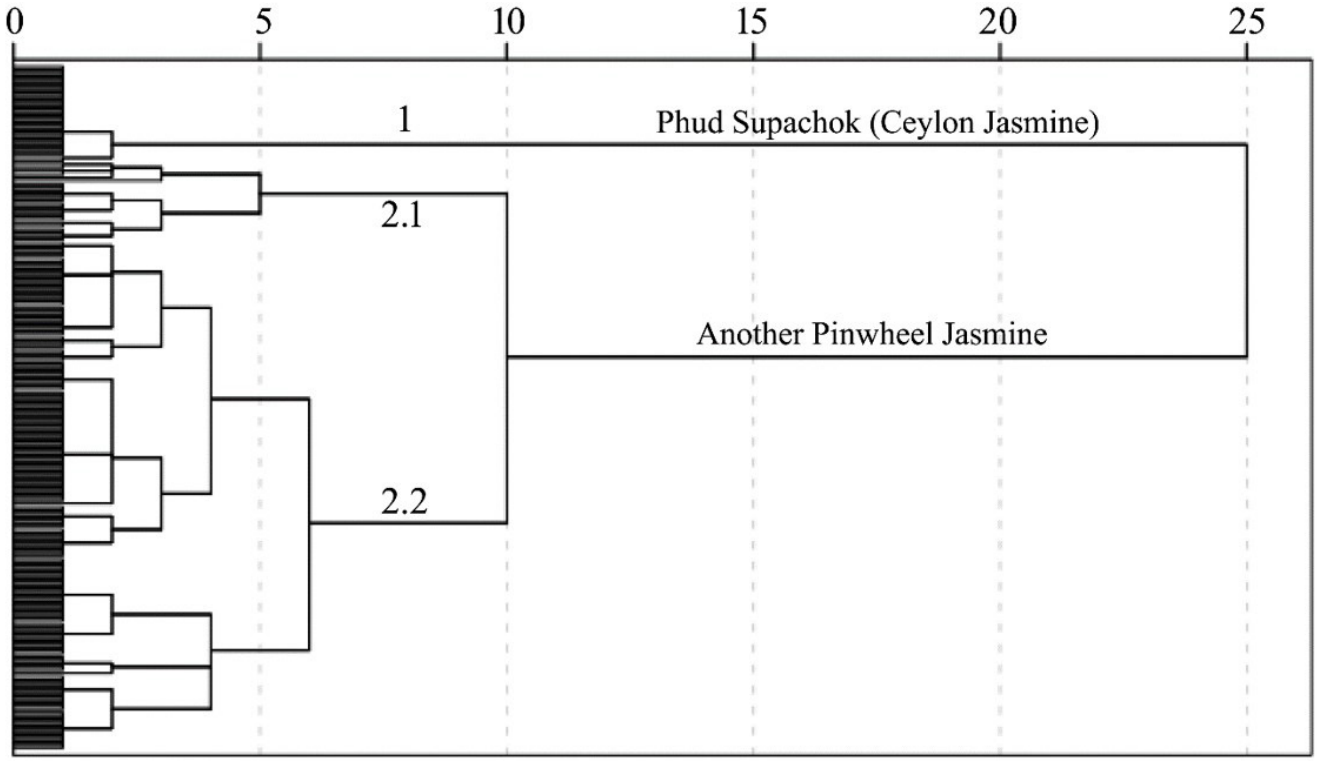

Figure 5. Dendrogram using average linkage (between groups) of *T. divaricata* in Thailand, supported by a 95% bootstrap value

Table 3. Results of F-tests for characters used in K-means cluster analysis of seven *T. divaricata* morphotypes in Thailand

Character	Cluster mean square	df	Error mean square	df	F	Sig.
LML	220823.608	1	546.445	209	404.109	<0.01
LMW	42050.67	1	129.425	209	432.903	<0.01
CLL	2171.912	1	6.631	209	327.541	<0.01
DCS	594.942	1	1.122	209	530.044	<0.01
STL	216.638	1	1.197	209	181.024	<0.01

Character abbreviations are defined in Table 1

clear morphological similarities between its members. However, two distinctive traits likely contributed to the separation of Subgroup 1 from Subgroup 2: in P2 (Sharp-petal Pinwheel), petals possess elongated, pointed tips (Figure 1B), while in P5 (Phud Malai), flowers often wilt while still in the bud stage (Figure 1D).

4. Discussion

The extensive morphological variation observed in *T. divaricata* in Thailand indicates that this species represents a complex of overlapping morphotypes. Seven morphotypes (P1–P7) were identified based on quantitative and qualitative traits, yet only P7 (Phud Supachok) consistently formed a distinct cluster in both cluster and discriminant analyses. Key traits differentiating P7 included leaf length (LML), leaf width (LMW), corolla lobe length (CLL), distance from corolla tube base to stamen attachment (DCS), and style length (STL). These characters are essential for reproductive success and may also reflect adaptive divergence in response to ecological and environmental pressures.

The variation observed among P1–P7 demonstrates that *T. divaricata* exhibits substantial morphological plasticity, likely influenced by genetic variation, environmental heterogeneity, and artificial selection associated with horticultural propagation (Duan *et al.* 2005; Bartkowicz & Paluch 2023; Napier *et al.* 2023). Differences in reproductive traits, including corolla size and petal arrangement, suggest differential selection pressures, potentially linked to pollinator interactions. At the same time, variations in leaf morphology may reflect adaptations to light availability and microhabitat conditions.

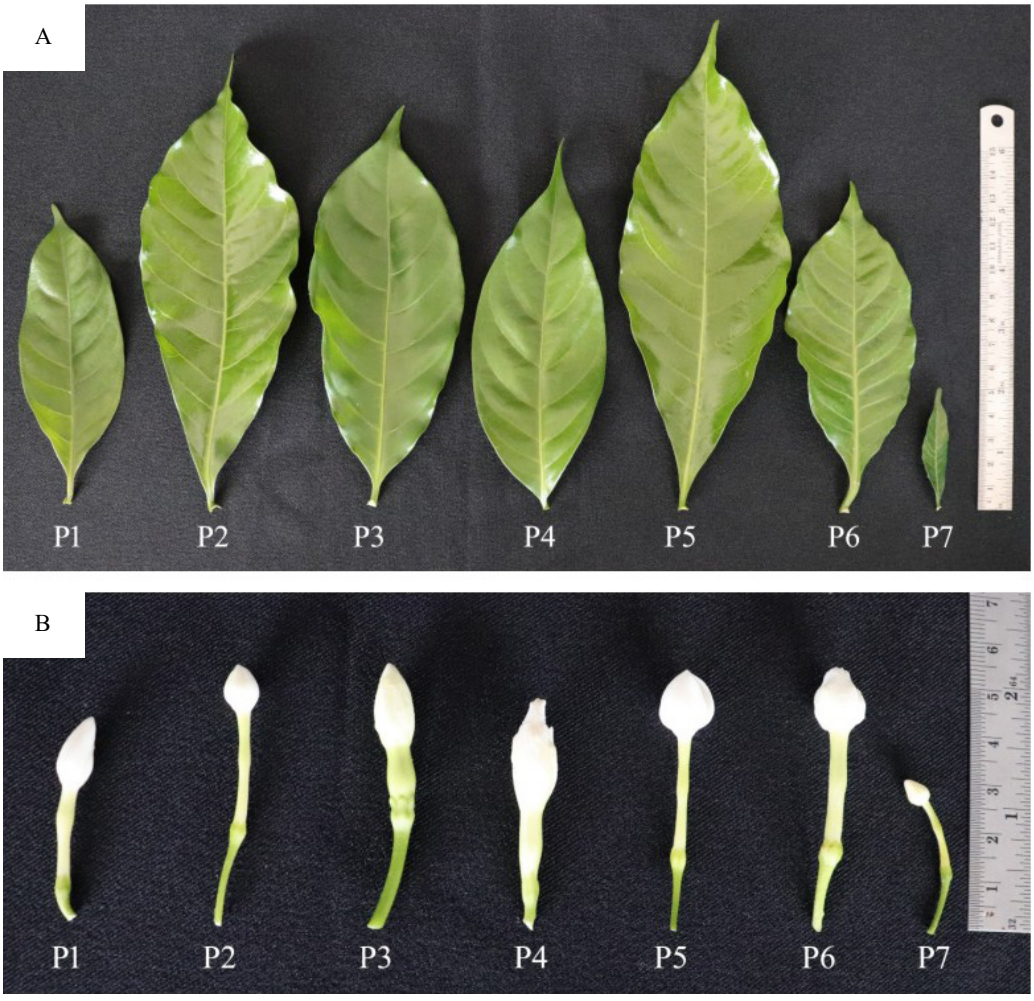

Figure 6. Variation in leaf (A) and flower bud (B) morphology among the seven phenotypes of *T. divaricata* in Thailand. (P1) Phud Suan, (P2) Phud Kung Hun, (P3) Phud Kulap, (P4) Phud Son, (P5) Phud Malai, (P6) Phud Saeng Chan, (P7) Phud Supachok

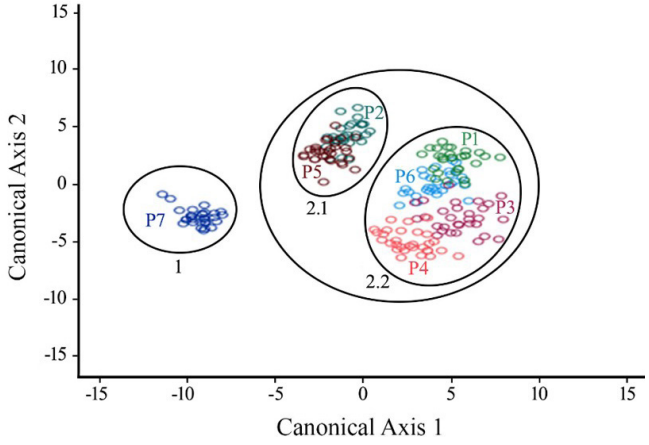

Figure 7. Scatter plot of 210 OTUs of the *T. divaricata* complex with 95% confidence intervals. (P1) Phud Suan, (P2) Phud Kung Hun, (P3) Phud Kulap, (P4) Phud Son, (P5) Phud Malai, (P6) Phud Saeng Chan, (P7) Phud Supachok

Subtle morphological differences among the remaining six morphotypes indicate overlapping phenotypes, supporting a continuum rather than discrete taxonomic boundaries. Similar patterns have been reported in other plant taxa, such as *Microsorum scolopendria, Thelypteris* species, *Eichhornia crassipes*, and wild papaya (*Vasconcellea pubescens*), where quantitative traits are more effective for distinguishing intraspecific groups, while qualitative traits aid in subgrouping (Sornsuwan *et al.* 2009; Petchsri *et al.* 2012; Tungmunnithum *et al.* 2017; Rifqi & Chasani 2024).

The consistent separation of P7 emphasizes its potential recognition as a distinct species. However, the taxonomic status of the other six morphotypes remains unresolved. Integrating molecular analyses,

such as DNA barcoding and phylogenomics, with morphometric data is necessary to clarify species boundaries, elucidate evolutionary relationships, and assess the influence of gene flow, hybridization, and human-mediated selection on morphological diversity (Backes *et al.* 2025; Kipkoech *et al.* 2025).

The consistent separation of P7 highlights its potential for further taxonomic evaluation. However, because this study relies solely on morphological data, integration with molecular approaches is recommended. Molecular studies in medicinal plants, such as *Zanthoxylum nitidum*, demonstrate that nuclear and chloroplast markers (*ITS* and *rbc*L) allow accurate delimitation of intraspecific clusters (Qin *et al.* 2022). Similarly, integrative analyses in the Neotropics, such as the *Pagamea guianensis* complex, show that combining genomic, morphological, ecological, and chemical data provides robust species delimitation (Prata *et al.* 2018). Applying comparable molecular and morphometric frameworks to *T. divaricata* would clarify species boundaries, assess hybridization, and improve understanding of evolutionary relationships.

Overall, this study demonstrates that combining quantitative and qualitative morphological analyses with numerical taxonomy provides a robust framework for resolving taxonomic ambiguities. These findings have important implications for horticulture, conservation management, and ecological research by enabling accurate morphotype identification and guiding propagation strategies for both ornamental and native populations of *T. divaricata.*

In conclusion, the survey of *T. divaricata* specimens revealed seven distinct morphological types. Quantitative and qualitative analyses of 40 vegetative and reproductive characters using numerical taxonomic techniques, including cluster analysis and discriminant analysis, indicated that P7 (*T. divaricata* 'Phud Supachok') is clearly distinct from the other morphotypes and may warrant recognition at the species level.

The remaining six morphotypes, however, exhibited overlapping morphological traits, making their taxonomic status less clear. Further studies, particularly using molecular genetic approaches, are recommended to clarify the phylogenetic relationships and confirm the taxonomic position of these morphotypes within the *T. divaricata* complex.

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