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Qiang WANG

A Monograph of the Genus *Microtoena* (Lamiaceae)

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The genus *Microtoena* is a lovely and enigmatic member of the mint family. This new monograph is a comprehensive taxonomic revision, based on extensive field observations, population sampling, specimen examinations, scanning electron microscopy observations, statistical analysis of characters, and molecular phylogenetic analysis. Detailed species descriptions are enhanced by 20 maps, 18 full page line drawings and numerous field photos. This is an essential reference for taxonomists, growers, breeders and horticulturalists.

Qiang WANG. Associate Professor at the State Key Laboratory of systematic and Evolutionary Botany, Institute of Botany, Chinese Academy of Sciences. A young taxonomist, his main interests are taxonomy, phylogeny and evolution of Lamiaceae, and his passion for *Microtoena* stretches back 10 years.

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DEDICATION

Dedicated to the ‘father’ of *Microtoena* and ex-director (1905–1922) of the Royal Botanic Gardens, Kew:

Dr. David Prain

PREFACE

The genus *Microtoena* is an enigmatic member of the mint family. Most species of this genus are rare and poorly collected in the field. Although this rare plant is not widely cultivated in most gardens, the lovely flowers of it are certainly attractive, both to the taxonomists and to the general public. Recent studies on chemical components of *Microtoena* reveal its huge potential in Medicine. Obviously, for a genus of such horticultural and medicinal importance, it is essential to have a scientifically sound taxonomy.

In the taxonomic history of *Microtoena*, more than thirty species and varieties have been described and reported. However, most of these taxa are poorly known, and the relationship between species was still unclear. The only taxonomic system of *Microtoena* was proposed about fifty years ago. Unfortunately, this taxonomic system with six series is not reliable, because it is mainly based on a few quantitative characters which are found to be unstable.

I have worked on this enigmatic genus for more than ten years and have carefully investigated nearly all the distribution areas of *Microtoena*. Based on extensive field observations, population sampling, critical examination of herbarium specimens, scanning electron microscopy (SEM) observations, and statistical analysis of all relevant characters, as well as molecular phylogenetic analysis, two sections with nineteen species are recognized here for *Microtoena*. In addition, twenty- two names of species and varieties are reduced to synonyms, and one species is excluded from *Microtoena*. Based on molecular phylogenetic analyses and reconstructions of ancestral states of diagnostic characters as well as distribution patterns, I traced evolutionary trends of a number of characters of taxonomic significance, and also inferred the biogeographical history of *Microtoena*.

It is to be hoped that the present monograph will stimulate the intensive study and conservation of these lovely plants. It is necessary for us to know such a rare, enigmatic, and important genus better, before we lose it.

Qiang WANG
Oct. 10, 2017

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CONTENTS

CHAPTER I. TAXONOMIC HISTORY AND QUESTIONS TO BE ADDRESSED

TAXONOMIC HISTORY

Before the establishment of *Microtoena*, some taxa of this genus had attracted the attention of taxonomists. The first species described was by Henry Fletcher Hance (1884) from Guangdong Province (China), as *Gomphostemma insuave* Hance. This was transferred to *Microtoena* by John Isaac Briquet (1895).

Sir Joseph Dalton Hooker (1885) described *Plectranthus patchouli* C.B. Clarke ex Hook. f. from Assam (India). However, he was suspicious about the position of this new species. Charles Baron Clarke (1889) commented that *P. patchouli* might be a species of *Cymaria* or a close relative. David Prain (1889) renamed it as *Microtoena cymosa* Prain, but this name is illegitimate. Finally, this species was correctly transferred to *Microtoena* by Shwe Jye Hsuan (1965), as *M. patchoulii* (C.B. Clarke ex Hook. f.) C.Y. Wu & S.J. Hsuan.

Adrien René Franchet (1887) described *Clerodendrum moupinense* Franch. from Sichuan Province (China). This species was later transferred to *Microtoena* by D. Prain (1895), as *M. moupinensis* (Franch.) Prain.

The establishment of *Microtoena* was in 1889. Two years before 1889, David Prain, later director (1905-1922) of the Royal Botanic Gardens, Kew, visited India to investigate commercial plants. The 'true Patchouli plant' of Clarke attracted Prain's attention, and he didn't agree with Hooker and Clarke, and thought that it was unjustifiable to place this species in *Plectranthus* or *Cymaria*. In his opinion, this plant should belong to a new genus. In 1889, D. Prain founded his new genus *Microtoena*, and transferred *P. patchouli* to *Microtoena*. In accordance with the 'Kew Rule' about the priority of epithets being limited to their use only within a particular genus, which permitted changing an epithet when a species was transferred for the first time from one genus to another, D. Prain rejected the epithet '*patchouli*' and renamed *P. patchouli* as *M. cymosa*, the first species name in *Microtoena*. The 'Kew Rule' has been rejected, and Prain's renaming is now illegitimate. S.J. Hsuan (1965) transferred *P. patchouli* into *Microtoena* as *M. patchoulii*, and reduced the name *M. cymosa* to a synonym.

William Botting Hemsley (1890) described two new species of *Microtoena* from

Hubei Province (China), based on the collections of Augustine Henry: *M. robusta* Hemsl. with robust stems and *M. urticifolia* Hemsl. with *Urtica*-like leaves.

At the same year, D. Prain (1890) described *M. griffithii* Prain as new, based on two specimens collected from Assam (India). The lectotype of *M. griffithii* designated in the present study, *Griffith 4059* [preserved in K (K 000928194)], might be the oldest collection of a *Microtoena*. It was collected by William Griffith in April 1863, approximately twenty-six years before the establishment of *Microtoena*.

Five years later, D. Prain (1895) described another new species*: M. delavayi* Prain with two varieties, var. *vera* Prain and var. *grandiflora* Prain. The name *M. delavayi* var. *vera* is invalid (Art. 24. 3), and the autonym *M. delavayi* var. *delavayi* should be accepted. In addition, D. Prain transferred *Clerodendrum moupinense* to *Microtoena*, as *M. moupinensis* (Franch.) Prain.

In the same year, J.I. Briquet (1895) regarded *Gomphostemma insuave* Hance as conspecific with *M. cymosa*. Therefore, he made the new combination, *M. insuavis* (Hance) Prain ex Briq., and reduced *M. cymosa* to synonymy.

Friedrich Ludwig Emil Diels (1900) described a new species from China, *M. prainiana* Diels. This species was collected from Jinfo Mountain, Nanchuan county, Chongqing City (China). This distinct species has glomerate cymes in ovoid panicles. It has also been found in other provinces of SW China, such as Sichuan, Yunnan, and Guizhou.

Augustine Abel Hector Léveillé (1911) described three new species: *M. mollis* H. Lév., *M. esquirolii* H. Lév., and *M. coreana* H. Lév.. Both *M. mollis* and *M. esquirolii* were collected from Guizhou Province (China), but *M. coreana* from Seoul City (South Korea) was far from SW China and SE Asia, the main distribution area of *Microtoena*. A.A.H. Léveillé was suspicious about this remote species, and marked it as a doubtful member of the genus.

Unaware of the combination of J.I. Briquet (1895) for *Gomphostemma insuave*, Stephen Troyte Dunn (1913) transferred *G. insuave* to *Microtoena* again, and combined it as *M. insuavis* (Hance) Prain ex Dunn, which is certainly illegitimate. In addition, S.T. Dunn regarded *M. cymosa*, *M. mollis*, and *M. esquirolii* as conspecific with *M. insuavis*, and reduced these names to synonyms.

Heinrich Raphael Eduard von Handel-Mazzetti (1936) described a new species and a new variety from China: *M. maireana* Hand.-Mazz. narrowly distributed in Huize County of Yunnan Province and *M. urticifolia* var. *subedentata* Hand.-Mazz., a poorly known taxon endemic to Nu Jiang region of Yunnan Province.

Cheng Yi Wu (1959) made the first taxonomic revision of *Microtoena* in China. In his revision, nine species and two varieties were recognized. C.Y. Wu followed S.T. Dunn (1913) and reduced *M. cymosa*, *M. mollis*, and *M. esquirolii* to synonyms of *M. insuavis*, and the invalid name *M. delavayi* var. *vera* to a synonym of *M. delavayi*. In addition, C.Y. Wu described two new species of *Microtoena*, *M. tenuiflora* C.Y. Wu

with slim flowers and *M. megacalyx* C.Y. Wu with a conspicuously dilated calyx.

Following the revision of C.Y. Wu, S.J. Hsuan (1965) made an updated taxonomic revision of *Microtoena* for China. In this revision, S.J. Hsuan added nine new species and four new varieties as follows: *M. pauciflora* C.Y. Wu, *M. subspicata* C.Y. Wu, *M. subspicata* var. *intermedia* C.Y. Wu & S.J. Hsuan, *M. delavayi* var. *lutea* C.Y. Wu & S.J. Hsuan, *M. delavayi* var. *amblyodon* C.Y. Wu & S.J. Hsuan, *M. affinis* C.Y. Wu & S.J. Hsuan, *M. albescens* C.Y. Wu & S.J. Hsuan, *M. muliensis* C.Y. Wu & S.J. Hsuan, *M. stenocalyx* C.Y. Wu & S.J. Hsuan, *M. omeiensis* C.Y. Wu & S.J. Hsuan, *M. vanchingshanensis* C.Y. Wu & S.J. Hsuan, *M. urticifolia* var. *brevipedunculata* C.Y. Wu & S.J. Hsuan, and *M. longisepala* C.Y. Wu. In addition, S.J. Hsuan made a new combination, *M. patchouli* (C.B. Clarke ex Hook. f.) C.Y. Wu & S.J. Hsuan (formerly *Plectranthus patchouli* and *Microtoena cymosa*), and separated it from *M. insuavis* as an independent species. Unfortunately, S.J. Hsuan was still unaware of Briquet's combination for *G. insuave* (J.I. Briquet, 1895), and took up the later illegitimate combination made by S.T. Dunn (1913), *M. insuavis* (Hance) Prain ex Dunn. S.J. Hsuan did not agree with S.T. Dunn on the reduction of *M. mollis* to a synonym of *M. insuavis*, and restored it as an independent species. She reduced *M. tenuiflora* to a synonym of *M. delavayi*. In Hsuan's revision, a taxonomic system with five series for Chinese *Microtoena* was proposed, which was mainly based on the morphology of the calyx.

Hsi Wen Li and C.Y. Wu (1977) described a monospecific series, ser. *Miyienses* C.Y. Wu & H.W. Li based on their new species *M. miyiensis* C.Y. Wu & H.W. Li. In addition, C.Y. Wu and H.W. Li separated *M. maireana* from ser. *Stenocalyces* C.Y. Wu & S.J. Hsuan, and transferred it into their new series.

William Thomas Stearn (1982) described a new species from Nepal, *Microtoena nepalensis* Stearn, which has extremely tiny bracts.

One year later, W.T. Stearn (1983) described three further new species of *Microtoena* from East Himalayan: *M. bhutanica* Stearn endemic to Bhutan, *M. siamica* Stearn endemic to Thailand, and *M. wardii* Stearn endemic to S Tibet.

In the *Flora of China* vol. 17, H.W. Li and Ian Charleson Hedge (1994) accepted 20 species and 5 varieties of *Microtoena* in China, mainly based on the revision of Hsuan (1965). In addition, they accepted the legitimate combination name *M. insuavis* (Hance) Prain ex Briq. for *G. insuave*. However, they improperly included its homonym *M. insuavis* (Hance) Prain ex Dunn as a synonym of *M. patchoulii*.

Based on specimen examination, extensive field observation, and careful analysis of a number of characters, De Yuan Hong and I (Wang & Hong, 2011) made a taxonomic revision on the most complicated group of *Microtoena*, the *M. insuavis* complex. In this revision, we confirmed the separation of *M. patchoulii* and *M. insuavis*, and restored *M. esquirolii* as independent species. In addition, we reduced *M. subspicata* and *M. subspicata* var. *intermedia* to synonyms of *M. esquirolii*, *M.*

pauciflora to a synonym of *M. patchoulii*, and *M. siamica* to a synonym of *M. insuavis* respectively.

In 2012, D.Y. Hong & I dealt with the identity of *M. affinis*, a species which has been extremely doubtful (Li & Hedge, 1994). Based on field investigations of the type localities of *M. affinis* and allied species, specimen examination, and statistical analysis of characters, it was reduced to a synonym of *M. delavayi* (Wang & Hong, 2012).

In 2015, I expounded the identity of *M. coreana* (Wang, 2015), a species which has long been extremely doubtful. A.A.H. Léveillé (1911), who described this species, was suspicious about its position. C.Y. Wu (1959) and S.J. Hsuan (1965) both thought that *M. coreana* should be excluded from *Microtoena*. My results showed that *M. coreana* was actually an element of *Tripora divaricata* (Maxim.) P.D. Cantino (formerly *Caryopteris divaricata* Maxim.), a species which was long placed in the family Verbenaceae. As a result, I excluded *M. coreana* from the genus *Microtoena*, and reduced it to a synonym of *T. divaricata*.

All the species and variety names of *Microtoena* referred above are summarized in the Table I-1.

Table I-1. Chronology of the genus *Microtoena*.

Authors (year)	new taxa recognized	Accepted name (the present study)
Hance (1884)	*Gomphostemma insuave* Hance	*M. insuavis* (Hance) Prain ex Briq.
Hooker (1885)	*Plectranthus patchouli* C.B. Clarke ex Hook. f.	*M. patchoulii* (C.B. Clarke ex Hook. f.) C.Y. Wu & S.J. Hsuan
Franchet (1887)	*Clerodendrum moupinense* Franch.	*M. moupinensis* (Franch.) Prain
Prain (1889)	*Microtoena cymosa* Prain *nom. illeg.*	*M. patchoulii* (C.B. Clarke ex Hook. f.) C.Y. Wu & S.J. Hsuan
Hemsley (1890)	*M. robusta* Hemsl. *M. urticifolia* Hemsl.	Accepted Accepted
Prain (1890)	*M. griffithii* Prain	*M. moupinensis* (Franch.) Prain
Prain (1895)	*M. moupinensis* (Franch.) Prain *M. delavayi* Prain *M. delavayi* var. *vera* Prain *nom. inval.* *M. delavayi* var. *grandiflora* Prain	Accepted Accepted *M. delavayi* Prain *M. delavayi* Prain
Briquet (1895)	*M. insuavis* (Hance) Prain ex Briq.	Accepted
Diels (1900)	*M. prainiana* Diels	Accepted
Léveillé (1911)	*M. mollis* H. Lév. *M. esquirolii* H. Lév. *M. coreana* H. Lév.	Accepted Accepted *Tripora divaricata* (Maxim.) P.D. Cantino
Dunn (1913)	*M. insuavis* (Hance) Prain ex Dunn. *nom. illeg.*	*M. insuavis* (Hance) Prain ex Briq.
Handel-Mazzetti (1936)	*M. maireana* Hand.-Mazz. *M. urticifolia* var. *subedentata* Hand.-Mazz.	*M. moupinensis* (Franch.) Prain *M. wardii* Stearn
Wu (1959)	*M. tenuiflora* C.Y. Wu *M. megacalyx* C.Y. Wu	*M. delavayi* Prain Accepted

continued

Authors (year)	new taxa recognized	Accepted name (the present study)
Hsuan (1965)	*M. pauciflora* C.Y. Wu ex S.J. Hsuan	*M. patchoulii* (C.B. Clarke ex Hook. f.) C.Y. Wu & S.J. Hsuan
	M. subspicata C.Y. Wu ex S.J. Hsuan	*M. esquirolii* H. Lév.
	M. subspicata var. *intermedia* C.Y. Wu ex S.J. Hsuan	*M. esquirolii* H. Lév.
	M. delavayi var. *lutea* C.Y. Wu & S.J. Hsuan	*M. wardii* Stearn
	M. delavayi var. *amblyodon* C.Y. Wu & S.J. Hsuan	*M. wardii* Stearn
	M. affinis C.Y. Wu & S.J. Hsuan	*M. delavayi* Prain
	M. albescens C.Y. Wu & S.J. Hsuan	Accepted
	M. stenocalyx C.Y. Wu & S.J. Hsuan	Accepted
	M. muliensis C.Y. Wu ex S.J. Hsuan	Accepted
	M. omeiensis C.Y. Wu & S.J. Hsuan	Accepted
	M. vanchingshanensis C.Y. Wu & S.J. Hsuan	Accepted
	M. urticifolia var. *brevipedunculata* C.Y. Wu & S.J. Hsuan	*M. brevipedunculata* (C.Y. Wu & S.J. Hsuan) Q. Wang
	M. longisepala C.Y. Wu ex S.J. Hsuan	*M. moupinensis* (Franch.) Prain
	M. patchoulii (C.B. Clarke ex Hook. f.) C.Y. Wu & S.J. Hsuan	Accepted
Wu & Li (1977)	*M. miyiensis* C.Y. Wu & H.W. Li	Accepted
Stearn (1982)	*M. nepalensis* Stearn	Accepted
Stearn (1983)	*M. bhutanica* Stearn	*M. delavayi* Prain
	M. siamica Stearn	*M. insuavis* (Hance) Prain ex Briq.
	M. wardii Stearn	Accepted

CIRCUMSCRIPTION AND PHYLOGENETICAL POSITION

In the taxonomic history of *Microtoena*, only four generic names have been involved in its circumscription, including *Clerodendrum*, *Gomphostemma*, *Plectranthus*, and *Tripora*. Before the establishment of *Microtoena*, three species of *Microtoena* had been described under the genera *Clerodendrum*, *Gomphostemma*, and *Plectranthus* respectively. These misplaced species were transferred to *Microtoena* soon after its establishment. Since then, no species of *Microtoena* has been described under any other genus. The last misplaced species, *Microtoena coreana*, was incorrectly included within *Microtoena*, and has been reduced to a synonym of *Tripora divaricata*. Obviously, in the taxonomic history, the circumscription of *Microtoena* is stable and without problem. In practice, *Microtoena* is a quite distinct genus. It can be easily recognized in the field by its dichotomous cymes and the remarkable upper lip of the corolla, which is laterally compressed galeate.

When founding the genus *Microtoena*, D. Prain (1889) thought his new genus was closely related to the genus *Craniotome*, so he transposed *Craniotome* into *Microtoena* as the name for this new genus. Therefore, the name *Microtoena* is actually a meaningless anagram, which was strongly criticized by Richard Thomas Lowe (1868). D. Prain (1889) placed his *Microtoena* in tribe Stachydeae, the fifth tribe in George Bentham's eight-tribe taxonomic system for Lamiaceae (Bentham, 1876). J.I. Briquet

(1897) proposed a widely accepted taxonomic system of Lamiaceae comprising eight subfamilies, and placed *Microtoena* and *Craniotome* in the subtribe Lamiinae, tribe Stachydeae of his sixth subfamily Stachyoideae. In the 'The Families and Genera of Vascular Plants-VII Lamiales' (Kadereit, 2004), Joachim Walter Kadereit placed *Microtoena* in subfamily Lamioideae (Harley, 2003).

Recent molecular phylogenetic studies (Scheen et al., 2010; Bendiksby et al., 2011) presented new evidence for the circumscription and phylogenetical position of *Microtoena*. Anne Cathrine Scheen et al. (2010) sampled only one species (*M. patchoulii*) from *Microtoena*. The results of their analysis based on three chloroplast DNA fragments (*trnL*, *trnL-F*, *rps16*) showed that *Microtoena* formed a clade with *Craniotome*, *Anisomeles* and *Pogostemon*, which nested in the tribe Pogostemoneae, subfamily Lamioideae. Based on the study of A.C. Scheen et al., Mika Bendiksby et al. (2011) added another chloroplast marker (*matK*) in their analysis. Besides *M. patchoulii,* M. Bendiksby sampled another species, *M. delavayi*. The result confirmed the relationship of *Microtoena*, *Craniotome*, *Anisomeles* and *Pogostemon*, and the position of *Microtoena* in Lamiaceae. Unfortunately, the results of M. Bendiksby et al. showed that the two species of *Microtoena* might be paraphyletic, although their resolution was weakly supported (JK < 50) and unclear. For the first time, the circumscription of this genus was challenged.

SUBDIVISION

The genus *Microtoena* is a poorly known group, most species of which are extremely rare in the field. The infrequence of *Microtoena* has lead to poor taxonomic study of *Microtoena* and no integrated subdivision has been proposed. S.J. Hsuan was the first taxonomist to subdivide *Microtoena*. In her taxonomic revision of *Microtoena* in China (Hsuan, 1965), She recognized five series for the Chinese species of *Microtoena*: ser. Cymosae; ser. *Robustae*; ser. *Stenocalyces*; ser. *Urticifoliae*, and ser. *Vanchingshanenses*. This system was supplemented by C.Y. Wu and H.W. Li (1977), who added ser. *Miyienses* to make a total of six series (Table I-2). The six-series system is mainly based on quantitative parameters of the calyx, such as the length of the calyx, and the length and width of the calyx teeth. However, the calyx and calyx teeth undergo continuous enlargement period after anthesis. There is a great risk to base a taxonomic system on these unstable quantitative characters.

Table I-2. The six-series taxonomic system of *Microtoena.*

Series name	Taxa included
ser. *Cymosae* (incl. 5 species & 1 variety)	*M. patchoulii, M. pauciflora, M. mollis, M. subspicata, M. subspicata* var. *intermedia, M. insuavis*
ser. *Miyienses* (monospecific series)	*M. miyiensis*

Data-15. The standard deviation analysis of corolla length of sampled populations.

Population	Species	Variation range	Mean	Standard deviation
H&W08004	*M. mollis*	1.40-1.60	1.513	0.063
H&W08005	*M. mollis*	1.24-1.64	1.500	0.091
H&W08006	*M. esquirolii*	1.02-1.53	1.303	0.162
H&W08007	*M. esquirolii*	1.33-1.63	1.489	0.103
H&W08009	*M. patchoulii*	1.45-1.49	1.477	0.017
H&W09001	*M. insuavis*	1.26-1.40	1.324	0.050
H&W09002	*M. insuavis*	1.30-1.37	1.328	0.025
H&W09003	*M. mollis*	1.44-1.51	1.485	0.029
H&W09004	*M. mollis*	1.33-1.71	1.538	0.119
H&W09006	*M. mollis*	1.42-1.77	1.539	0.091
H&W09007	*M. moupinensis*	2.75-3.67	3.016	0.280
H&W09008	*M. moupinensis*	2.70-3.44	3.004	0.253
H&W09010	*M. patchoulii*	1.43-1.56	1.507	0.036
H&W09011	*M. patchoulii*	1.48-1.52	1.490	0.013

Data-16. The standard deviation analysis of corolla length of species.

Species	Variation range	Mean	Standard deviation
1. *M. esquirolii*	1.02-1.63	1.361	0.143
2. *M. insuavis*	0.78-1.40	1.191	0.166
3. *M. patchoulii*	1.10-1.64	1.438	0.123
4. *M. mollis*	1.24-1.77	1.530	0.096
5. *M. delavayi*	1.47–2.53	2.026	0.305
6. *M. wardii*	1.47-2.28	1.855	0.266
7. *M. urticifolia*	1.62-2.64	2.015	0.422
8. *M. albescens* (holotype)	2.08	—	—
9. *M. stenocalyx*	1.91-2.48	2.201	0.165
10. *M. miyiensis* (holotype)	2.18	—	—
11. *M. megacalyx*	1.73-2.70	2.297	0.370
12. *M. moupinensis*	1.64-3.67	2.829	0.420
13. *M. prainiana*	1.62-2.54	2.163	0.230
14. *M. muliensis*	1.66-2.60	1.994	0.272
15. *M. omeiensis*	1.67-2.75	2.326	0.356
16. *M. brevipedunculata*	1.79-1.85	1.822	0.029
17. *M. nepalensis*	1.87-2.36	2.103	0.168
18. *M. robusta*	1.48-2.16	1.906	0.265
19. *M. vanchingshanensis*	1.68-1.76	1.714	0.036

Data-17. The standard deviation analysis of corolla tube ratio of sampled populations.

Population	Species	Variation range	Mean	Standard deviation
H&W08004	*M. mollis*	0.12-0.17	0.138	0.016
H&W08005	*M. mollis*	0.11-0.17	0.130	0.014
H&W08006	*M. esquirolii*	0.16-0.19	0.177	0.009
H&W08007	*M. esquirolii*	0.18-0.20	0.188	0.007
H&W08009	*M. patchoulii*	0.19-0.24	0.214	0.014
H&W09001	*M. insuavis*	0.12-0.15	0.135	0.010
H&W09002	*M. insuavis*	0.11-0.13	0.124	0.006
H&W09003	*M. mollis*	0.11-0.15	0.127	0.012
H&W09004	*M. mollis*	0.11-0.15	0.126	0.014
H&W09006	*M. mollis*	0.11-0.16	0.127	0.012
H&W09007	*M. moupinensis*	0.66-0.71	0.683	0.013
H&W09008	*M. moupinensis*	0.63-0.72	0.674	0.022
H&W09010	*M. patchoulii*	0.19-0.24	0.218	0.012
H&W09011	*M. patchoulii*	0.18-0.24	0.214	0.023

Data-18. The standard deviation analysis of corolla tube ratio of species.

Species	Variation range	Mean	Standard deviation
1. *M. esquirolii*	0.16-0.20	0.183	0.009
2. *M. insuavis*	0.11-0.15	0.128	0.008
3. *M. patchoulii*	0.18-0.25	0.220	0.014
4. *M. mollis*	0.11-0.17	0.128	0.013
5. *M. delavayi*	0.51-0.64	0.577	0.031
6. *M. wardii*	0.59-0.66	0.621	0.021
7. *M. urticifolia*	0.52-0.55	0.531	0.010
8. *M. albescens* (holotype)	0.59	—	—
9. *M. stenocalyx*	0.52-0.57	0.542	0.017
10. *M. miyiensis* (holotype)	0.62	—	—
11. *M. megacalyx*	0.52-0.55	0.528	0.012
12. *M. moupinensis*	0.63-0.72	0.677	0.016
13. *M. prainiana*	0.54-0.63	0.581	0.023
14. *M. muliensis*	0.51-0.54	0.525	0.011
15. *M. omeiensis*	0.60-0.65	0.621	0.016
16. *M. brevipedunculata*	0.52-0.55	0.535	0.013
17. *M. nepalensis*	0.48-0.53	0.509	0.020
18. *M. robusta*	0.53-0.58	0.552	0.020
19. *M. vanchingshanensis*	0.55-0.58	0.566	0.013