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FLORAL MORPHOLOGY AND RECOGNITION OF VARIETIES IN *CONANDRON RAMONDIOIDES* (*GESNERIACEAE*) FROM JAPAN AND TAIWAN

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Comparisons of corolla morphology were made between plants of *Conandron ramondioides* (*Gesneriaceae*) from 23 localities in Japan and Taiwan. Lobe-length to tube-length ratios were found to correlate with geographical distribution and support the recognition of two previously described varieties: var. *ramondioides* in mainland Japan (lobe length less than twice tube length) and var. *taiwanensis* from Iriomote Island (Japan) and Taiwan (lobe length more than three times tube length). Mitotic chromosomes were also observed but no differences were seen between accessions, all of which had $2n = 32$.

Keywords. *Conandron*, corolla, *Gesneriaceae*, Japan, Ryukyu Islands, Taiwan, taxonomy, varieties.

INTRODUCTION

The genus *Conandron* Siebold & Zucc. (*Gesneriaceae–Cyrtandroideae*) is monotypic, containing only *C. ramondioides* Siebold & Zucc. from China, Japan and Taiwan. In the Ryukyu Archipelago between Kyushu (Japan) and Taiwan this species occurs only in Yakushima and Iriomote Islands (Fig. 1). Masamune (1939, 1955) described two varieties, var. *taiwanensis* Masamune and var. *ryukuensis* Masamune, based on plants from Taiwan and Iriomote, respectively. However, his treatments have not been followed by all taxonomists. In this study we examined floral morphology in detail and reconsidered the infraspecific delimitation of *Conandron* in Japan and Taiwan.

TAXONOMIC BACKGROUND

In 1843 Siebold and Zuccarini described *Conandron ramondioides* based on a specimen from 'Japan proper' without any clear indication of the type locality. In the herbarium at M, we examined a syntype of this species but the type locality was not indicated on this specimen either.

In 1939, Masamune distinguished Taiwanese plants from those in Japan as having leaves almost sessile and pedicels covered with scaly hairs, and he described

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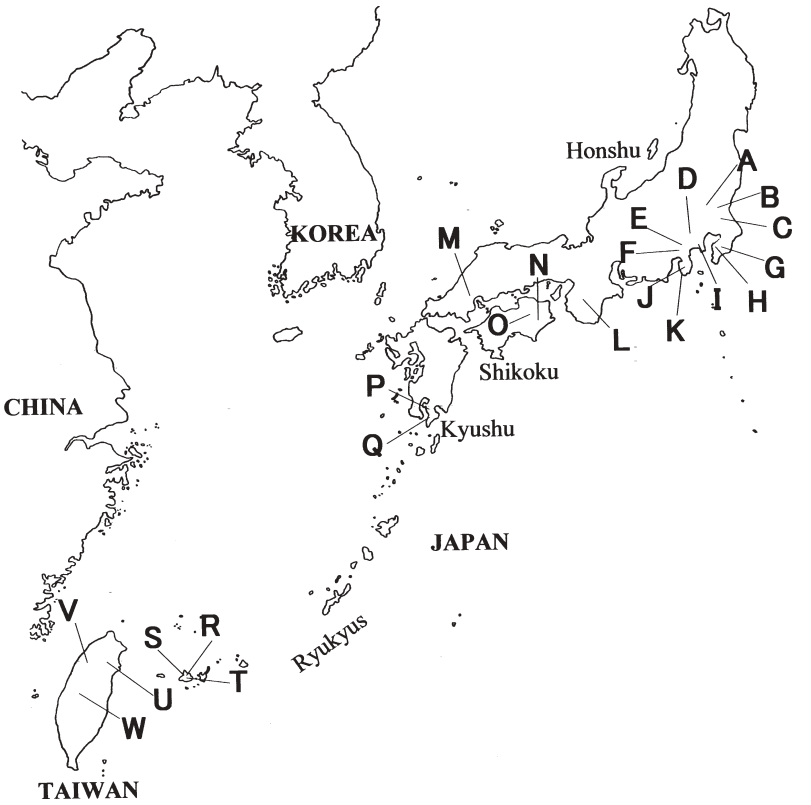

FIG. 1. Map of NE Asia showing localities of the 23 accessions investigated. Each letter refers to a locality listed in Table 1.

C. ramondioides var. *taiwanensis* Masamune based on a specimen from Tahu ('Tafu', Miaoli County, Taiwan; *Kawakami, Hayata & Mori* 76, TAI). In the same paper he suggested that plants from Iriomote should be recognized under the name *C. ramondioides* var. *ryukuensis* Masamune but as he provided no description it was a *nomen nudum*. In 1955, Masamune distinguished the Iriomote plants as having non-undulate and non-serrulate leaf margins, and formally described *C. ramondioides* var. *ryukuensis* Masamune. During this study, we found a specimen collected from Mt. Tedou-dake, Iriomote in 1931 (*Fukuyama* 7314) in the herbarium at TAI. The specimen was annotated as 'type' in ink and labelled '*Conandron iriomotensis*'. Although Masamune (1939, 1955) did not designate a type specimen, it is possible that he based var. *ryukuensis* on *Fukuyama* 7314.

Although Masamune's treatments (1939, 1955) were taken up by Takamine (1952), Hatusima & Amano (1967) and Hatusima (1975), they were not followed by all taxonomists. Yamazaki (1993) and Shimabuku (1997) recognized *C. ramondioides* var. *taiwanensis*, but treated var. *ryukuensis* as a synonym of var. *taiwanensis*. Makino (1962), Ohwi (1978, 1992), Walker (1974), Kao & Devol (1978), Li & Kao

(1998) and Wang *et al.* (1998) recognized neither variety. Yamazaki (1999) considered leaf morphology too variable to be useful in separating infraspecific taxa. Kokubugata (2002) reported that it is not possible to distinguish Iriomote and Taiwan plants from the other Japanese ones simply by leaf and peduncle characters as suggested by Masamune (1939, 1955), but implied that it was desirable to reinstate the two varieties.

Materials and methods

Plants of *Conandron ramondioides* were collected from 23 localities in Japan and Taiwan (Table 1 and Fig. 1). Living plants were maintained in the experimental glasshouses of Tsukuba Botanical Garden, National Science Museum, Tokyo and the Institute of Botany, Academia Sinica, Taipei. Voucher herbarium specimens were deposited at TNS (National Science Museum, Tokyo) and HAST (Herbarium, Academia Sinica, Taipei). Specimens from L (Nederlands National Herbarium, Leiden), M (Botanische Staatssammlung Muenchen), RYU (Faculty of Science, University of the Ryukyus) and TAI (Herbarium, National Taiwan University) were also examined.

Floral colour and morphology

Colour and morphological characters were observed in all accessions. The flowers were fixed in FAA after corolla and anther colours had been recorded. To measure lengths of corolla tube and corolla lobe, longitudinal cuts were made in the corollas with a small scalpel after fixing, and corolla ratios (corolla lobe length/corolla tube length) were then calculated (Fig. 2).

Cytology

Root tips were harvested and pretreated in 2mM 8-hydroxyquinoline at 20ºC for 2 hours. They were then fixed in 45% acetic acid at 20°C for 10 s, and macerated in a mixture of 1N hydrochloric acid and 45% acetic acid (2:1) at 60°C for 10 s, put on slides and stained in aceto-orcein at 20°C for 4 hours. Chromosomes at mitotic metaphase were observed by the squash method.

Results and discussion

Floral colour and morphology

Some differences in anther colour and intensity of corolla colour were apparent, presumably due to variation in anthocyanin levels. As this is known to be polymorphic in many plants (Bohm, 1987) we decided that this character was too plastic to be useful in delimiting infraspecific taxa.

TABLE 1. Accessions of *Conandron ramondioides* investigated

Collection locality	Collection no.*	Reference†	Corolla ratio‡
Japan, Honshu: Hotokenosawa, Shioya, Tochigi	*Kokubugata* 1285	A	1.1
Japan, Honshu: Kosaka, Kuji, Ibaraki	*Kokubugata* 4989	B	1.4
Japan, Honshu: Mt. Tsukubasan, Tsukuba, Ibaraki	*Kokubugata* 530	C	1.1
Japan, Honshu: Kuroyama-santaki, Hanno, Saitama	*Kokubugata* 540	D	1.2
Japan, Honshu: Mt. Takaoyama, Hachiohji, Tokyo	*Kokubugata* 575	E	1.5
Japan, Honshu: Mt. Musugamaru, Ashigakami, Kanagawa	*Yukawa* 99-68	F	1.3
Japan, Honshu: Hachirozuka, Kimitsu, Chiba	*Yukawa* 99-68	G	1.1
Japan, Honshu: Obitsu River, Kimitsu, Chiba	*Kokubugata* 482	H	1.3
Japan, Hoshu: Numama, Kamakura, Kanagawa	*Kokubugata* 1277	I	1.2
Japan, Honshu: Mt. Chokuro, Matsuzaki, Shizuoka	*Kokubugata* 99	J	1.3
Japan, Honshu: Shirakawa, Kamikitayama, Yoshino, Nara	*Kokubugata* 104	K	1.4
Japan, Honshu: Hogando, Matsuzaki, Shizuoka	*Kokubugata* 836	L	1.4
Japan, Hoshu: Ugakyo, Asakita, Hiroshima	*Kokubugata* 1276	M	0.9
Japan, Shikoku: Mt. Takagoemaya, Oe, Tokushima	*Kokubugata* 837	N	1.2
Japan, Shikoku: Aioi, Kaga, Tokushima	*Kokubugata* 838	O	1.3
Japan, Kyushu: Mt. Ohonogaradake, Kanoya, Kagoshima	*Kokubugata* 1301	P	1.5
Japan, Kyushu: Shiromoto, Ohnejime, Kagoshima	*Kokubugata* 836	Q	1.7
Japan, Ryukyu: Hinai Fall, Iriomote, Okinawa	*Kokubugata* 251	R	3.7
Japan, Ryukyu: Urauchi, River, Iriomote, Okinawa	*Kokubugata* 184	S	4.0
Japan, Ryukyu: Mt. Komi, Iriomote, Okinawa	*Kokubugata* 183	T	4.7
Taiwan, Mt. Papokulushan, Tatung, Ilan	*Leong* 2927	U	3.5
Taiwan, Mt. Five Finger, Wufong, Hsinchu	*Kokubugata* 5124	V	3.3
Taiwan, Mt. Fenghuangshan, Chitou, Nantou	*Peng* 17957	W	3.8

**Leong* 2927 and *Peng* 17957 are deposited at HAST; the rest are at TNS.
†Used in Fig. 1 to indicate collection localities.
‡Corolla ratio = corolla lobe length/corolla tube length.

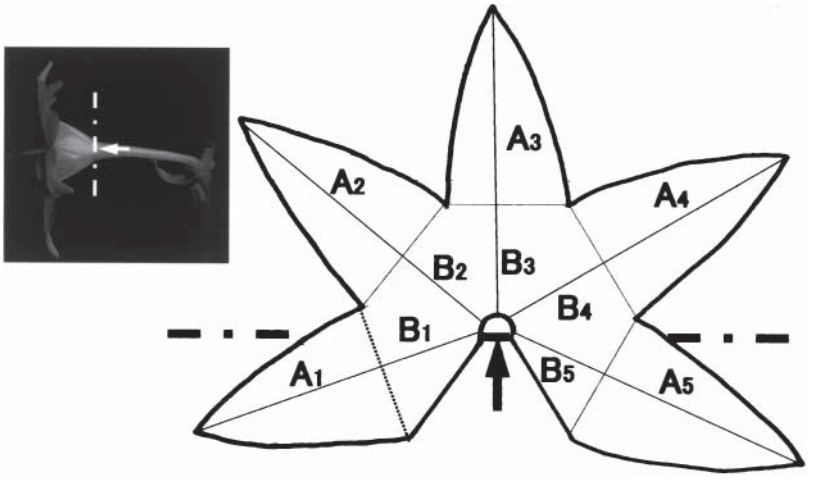

FIG. 2. Details of corolla measurements. Length of corolla lobe = (A1+A2+A3+A4+A5)/5; length of corolla tube = (B1+B2+B3+B4+B5)/5.

The flowers all had 5 syngenesious stamens with filaments attached near the base of the corolla tube and surrounding the style. The corollas were actinomorphic, tubular and 5-lobed. The corolla ratios shown in Table 1 and Fig. 3 allow the accessions to be clearly divided into two groups. The first group consists of six accessions, three from Iriomote and three from Taiwan, all with corolla ratios ranging from 3.3 to 4.0. The second group consists of the remaining 17 Japanese plants, with corolla ratios from 0.9 to 1.7. Student's *t*-test revealed a significant difference between the two groups ($P < 0.001$).

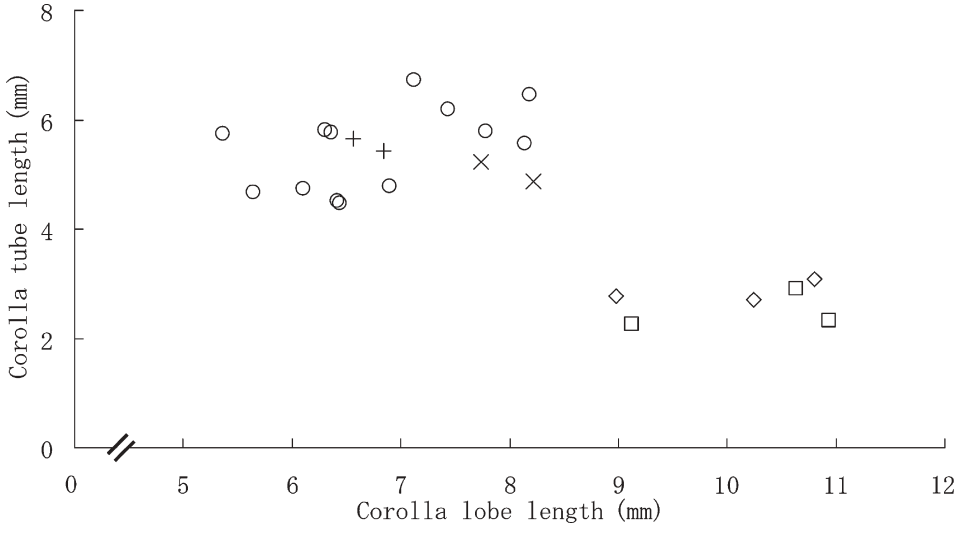

FIG. 3. Corolla tube and lobe lengths of plants investigated. ○, Honshu (Japan); +, Shikoku (Japan); ×, Kyushu (Japan); □, Iriomote (Ryukyus, Japan); ◇, Taiwan.

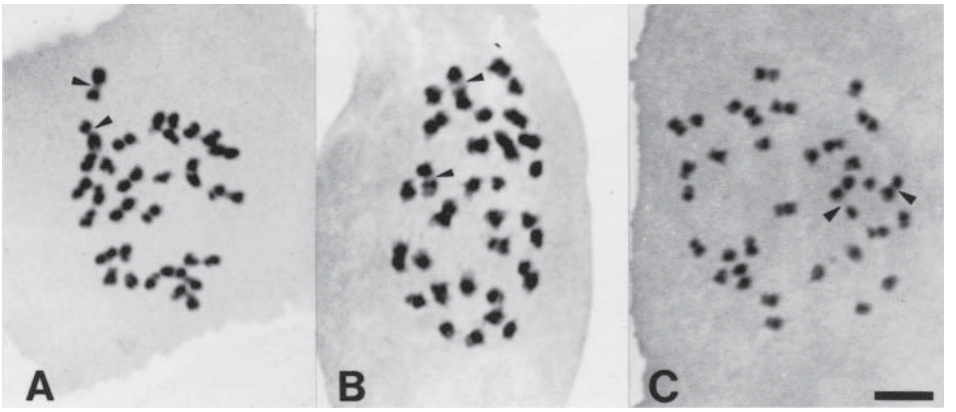

FIG. 4. Somatic chromosomes of *Conandron ramondioides*. A, Mt. Chokuro-yama (Honshu, Japan; *Kokubugata* 99); B, Hinai-taki Fall (Iriomote, the Ryukyus, Japan; *Kokubugata* 251); C, Mt. Fenghuangshan (Nantou, Taiwan; *Peng* 17957). Scale bar = 10μm.

Corollas in the type specimens of *C. ramondioides* var. *ramondioides* (*Siebold* s.n., M), var. *taiwanensis* (*Kawakami, Hayata & Mori* 76, TAI) and var. *ryukuensis* (*Fukuyama* 7314, TAI) were unfortunately absent or not measurable.

Chromosome characters

All 23 plants had $2n = 32$, corresponding with Ratter & Prentice (1964). They commonly showed a pair of chromosomes with pericentric secondary constrictions (Fig. 4, arrowed). No significant differences in chromosome characters were observed.

CONCLUSIONS

The corolla ratios of the Iriomote and Taiwan plants were significantly different from those of the 17 Japanese plants. We suggest that the former are separable at varietal level following Yamazaki (1993) and Shimabuku (1997). It is worth noting that the corolla drawn in the protologue of *Conandron ramondioides* (Siebold & Zuccarini, 1843) is clearly more like those from Honshu, Shikoku and Kyushu (Japan) than those from Iriomote (Japan) and Taiwan in corolla morphology. In conclusion, the Iriomote and Taiwan plants are best treated as *C. ramondioides* var. *taiwanensis* (Masamune, 1939).

Lectotypifications

Siebold & Zuccarini (1843) did not designate a type specimen when describing *C. ramondioides*. We examined eight Siebold specimens: one in the herbarium at M

and seven others at L. From these we selected the specimen at M (*Siebold* s.n.) as the lectotype of *C. ramondioides*.

As *Fukuyama* 7314, collected from Mt. Tedou-dake, Iriomote in 1931, was almost certainly consulted by Masamune when describing *C. ramondioides* var. *ryukuensis* (see Taxonomic background, above), we selected this specimen as the lectotype of *C. ramondioides* var. *ryukuensis*.

Key to the varieties of Conandron ramondioides
in Japan and Taiwan

1a. Corolla lobe less than twice as long as corolla tube ——— **1a.** var. **ramondioides**
1b. Corolla lobe more than three times as long as corolla tube — **1b.** var. **taiwanensis**

1a. Conandron ramondioides Siebold & Zucc. var. **ramondioides**, Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 3: 730, pl. 3 (1843); Yamazaki, Fl. Japan IIIa: 378 (1993); Shimabuku, Check List Vascular Fl. Ryukyu Is.: 522 (1997).
Lectotype: 'Japan proper', *Siebold* s.n., no date (M).

Distribution. Japan (Honshu, Shikoku and Kyushu).

Chromosome number. $2n = 32$.

Additional specimens examined. JAPAN. **Honshu**: **Iwate**: Hamaiwa-izumi, 29 ix 1967, *M. Kikuchi* s.n. (TNS). **Toyama**: Toshiga, 25 vi 1959, *N. Satomi* 12920 (TNS); Ohmaki, Toshiga, 20 vi 1951, *N. Satomi* 6154 (TNS). **Ishikawa**: Ajika-dani, Torikoshi, 25 v 1958, *N. Satomi* 10345 (TNS). **Fukui**: Imojyou, Nanjyou, 1971, *N. Kurosaki* 4592 (TNS); Shinjo, Mihama, vii 1955, *Y. Hori* s.n. (TNS). **Tochigi**: Nikko, viii 1883, *H. Sakurai* 11133 (TNS). **Gunma**: Mt. Myogi-yama, Shimonita, 23 viii 1916, *M. Nakamura* s.n. (TNS). **Saitama**: Kawamata, Chichibu, 10 viii 1971, *K. Saito & M. Yoshida* s.n. (RYU); Ohchi-gawa, Chichibu, 17 viii 1948, *T. Nakai* s.n. (TNS). **Ibaraki**: Mt. Tsukuba-san, Tsukuba, viii 1882, *H. Sakurai* s.n. (TNS). **Chiba**: Mt. Kiyosumi-yama, 26 vi 1960, *S. Asano* s.n. (TNS). **Tokyo**: Mt. Kariyori-yama, Nishitama, 19 ix 1958, *A. Saito* s.n. (TNS); Kurasawa, Okutama, 9 viii 1953, *T. Okawa* s.n. (TNS); Mt. Takao-san, Hachijoji, 26 vi 1959, *H. Ogi* s.n. (TNS). **Kanagawa**: Kamakura, 11 v 1947, *N. Satomi* 2843 (TNS); Mt. Sefuko-yama, 15 ix 1961, *S. Okumura* 16491 (TNS). **Shizuoka**: Chokuro-yama, Matsuzaki, 2 vi 1971, *F. Konta* 9276 (TNS); Cyoja-dake, Fuji, 15 vii 1984, *T. Sato* 5778 (TNS); Mt. Fudo-san, Honkawano, 30 vii 1978, *H. Koyama, E. Miki & T. Yahara* 136 (TNS); Funazawa to Tochizawa, Shizuoka-shi, 30 ix 1996, *F. Konta* 195 (TNS); Igawa, Shizuoka-shi, 28 vii 1973, *Y. Saiki, T. Noyo & K. Morigawa* 3225 (TNS); Jyoren, Amagiyugashima, 4 viii 1970, *M. Ichikawa, T. Fujimura & F. Konta* 1384 (TNS); Kamizuma, Sakuma, 20 vii 1982, *S. Kurosawa* 42 (TNS); Kakesubata, Fujinomiya, 29 iv 1976, *F. Konta* 10794 (TNS); Mt. Kento-yama, Numazu, 15 vi 1991, *F. Konta & K. Koguchi* 258 (TNS); Mt. Kuno-yama, Shizuoka-shi, 20 vi 1956, *J. Sugimoto* s.n. (TNS); Mt. Mafuji-dake, Nekko to Kyo-amagi, Amagiyugashima, 3 viii 1970, *M. Iohikewa, T. Fujimura & F. Konta* 1350 (TNS); Misakubo, Iwata, 28 vii 1974, *K. Konodo, N. Fukui & J. Fukui* 334 (TNS); Mt. Ogasa-yama, Kakegawa, 4 viii 1963, *N. Satomi* 22712 (TNS); Sakuma, Iwata, 2 viii 1972, *Y. Yoshida* 153 (TNS); Sekino-sawa, Umegashima, 20 x 1968, *H. Takahashi* 425 (TNS); Senzu to Ohma, 21 vii 1967, *H. Furuoya* 30 (TNS); Shiraitono-taki, Fujinomiya, 7 viii 1983, *T. Sato* 3550 (TNS); Sumata, Honkawane, 23 vii 1969, *F. Konta* 7857 (TNS); Tamuki-ko, Fujinomiya, 31 viii 1975,

F. Konta 11524 (TNS); Mt. Ushihara-yama, 15 ix 1981, *T. Sato* 707 (TNS); Uri-jima, Arakawa, 21 vii 1985, *T. Sato* 8447 (TNS); Yae-sawa, Shizuoka-shi, 19 vii 1968, *F. Konta & S. Hatano* 773 (TNS). **Nagano**: Chiyo, Iida, 16 ix 1934, *Koidumi* s.n. (TNS); Hiraoka, Shinano, 19 ix 1934, *Koidumi* s.n. (TNS); Ohjika, Shimoina, 8 ix 1923, *Koidumi* s.n. (TNS); Komaga-dake, Yamanashi, Miami-karuizawa, 21 vii 1936, *K. Shirai* s.n. (TNS); Toyama-gawa, Wada, 17 vii 1948, *M. Matsumura* 1091 (TNS). **Gifu**: Nishigabora, Itadori, 20 vii 1995, *H. Takahashi* 16205 (TNS); Kaore-dani, Itadori, 16 viii 1964, *M. Hotta & Y. Inamasu* 143 (TNS). **Mie**: Yamatodani, Miyagawa, 15 x 1994, *G. Murata* 71444 (TNS); Akama, Nabari, 18 vii 1965, *F. Konta* 5240 (TNS). **Kyoto**: Kibune, 20 viii 1950, *M. Togashi & H. Kudo* 102 (TNS); Yuku-tani, 16 ix 1993, *Ayabe, S. Tsugaru & M. Sawada* 19128 (TNS). **Wakayama**: Koya-ryujin, Ryujin, 15 x 1989, *T. Takahashi, H. Murakami & T. Yoneda* 1405 (TNS); Mt. Nati-yama, Kachiura, 13 x 1942, *Y. Satake & H. Okuyama* s.n. (TNS). **Hiroshima**: Ryuto-taki, 21 viii 1930, *M. Nishiyama* s.n. (TNS); Sandan-kyo, Yamagata, 9 x 1970, *G. Murata, K. Iwatsuki, M. Wakabayashi, M. Kato & N. Fujita* 171 (TNS). **Yamaguchi**: Mt. Monju-yama, Ohshima, 10 viii 1960, *K. Oka* 14570 (TNS); Kitani, Hirose, 13 x 1919, *S. Nikaido* s.n. (TNS). **Shikoku**: **Tokushima**: Todoroki-daki, 8 x 1943, *H. Okumura* s.n. (TNS). **Ehime**: Mt. Kuman-yama, viii 1889, *T. Nagasawa* s.n. (TNS). **Kochi**: Kuroson, 3 x 1959, *S. Okumura* 15735 (TNS). **Kyusyu**: **Oita**: Wakayama-dani, Beppu, 8 viii 1935, *H. Koidzumi* s.n. (TNS).

UNKNOWN LOCALITIES. *Bürger* s.n. (1825–1834*, L), *Bürger* s.n. (1825–1834*, L), *Bürger* s.n. (1825–1834*, L), *Siebold* s.n. (1823–1829*, L), *Siebold* s.n. (1823–1829*, L), *Siebold & unknown Japanese* s.n. (1823–1829*, L); *unknown Japanese* s.n. (date unknown, L). *Estimated years taken from Yamaguchi (2003).

1b. Conandron ramondioides Siebold & Zucc. var. ***taiwanensis*** Masamune, Trans. Nat. Hist. Soc. Formosa 29: 64 (1939); Yamazaki, Fl. Japan IIIa: 378 (1993); Shimabuku, Check List Vascular Fl. Ryukyu Is.: 522 (1997). Holotype: Taiwan, Miaoli, Tahu, 1 viii 1908, *Kawakami, Hayata & Mori* 76 (TAI).

Syn.: *C. ramondioides* var. *ryukuensis* Masamune, Sci. Rep. Kanazawa Univ. 5: 69–71 (1955); Takamine, Coll. Ryukyu For. Exp. Sta. 1: 98 (1952); Hatusima & Amano, Fl. Okinawa, revised edition: 105 (1967); Hatusima, Fl. Ryukyus: 555 (1975).

Distribution. Iriomote Island (Japan) and Taiwan.

Chromosome number. $2n = 32$.

Additional specimens examined. JAPAN. **Ryukyu Islands**: Aira-gawa, Iriomote, 1 vi 1973, *S. Kurata & T. Nakaike* 263 (TNS); Hinai-taki, Iriomote, 31 v 1973, *A. Yamamoto* s.n. (TNS); Iriomote, vii 1923, *G. Koidzumi* s.n. (TNS); Iriomote, 23 viii 1967, *Y. Miyagi* 3639 (RYU); Mt. Komi-dake, Iriomote, 29 vii 1961, *K. Oka* 16155 (TNS); Nakaragawa, Iriomote, 21 iv 1973, *M. Furuse* 2988 (RYU); Mt. Tedou-dake, Iriomote, 4 vi 1938, *N. Fukuyama* 7314 (TAI); Urauchi-gawa, Iriomote, 27 vi 1953, *T. Amano* 7182 (TNS).

TAIWAN. **Nantou**: Chitou, 17 x 1917, *M.-T. Kao* 7737 (TAI); Jijli, 15 iii 1992, *C.-C. Wang* 923 (HAST); Shanlinchi, 23 vii 1987, *S.-F. Huang & S.-Y. Yang* 3746 (TAI). **Chiayi**: Chiehtung to Mt. Tienyun-shan, 1 xi 1985, *C.-I. Peng* 8800 (HAST); Fenchifu to Tianchien, Chuchi, 17 vii 1997, *S.-D. Shen & Y.-J. Chen* 176 (HAST); Mt. Alishan, 14 x 1970, *M.-T. Kao* 7721 (TAI); Tingpinlin, Tapu, 12 ix 1992, *H.-F. Yen* 6615 (HAST). **Taichung**: Mt. Tahsueh-shan, 22 vii 1998, *S.-P. Li* 629 (TNM). **Miaoli**: Malabangshan, 31 v 1992, *T.-C. Huang & S.-F. Huang* s.n. (TAI); Mt. Taoshan, 26 vii 1984, *C.-F. Shieh* 612 (TAIF).

It was not possible to include any plants from mainland China in this investigation because none with observable corollas were found during field work or herbarium surveys. According to Wang *et al.* (1998), this species is recorded from Anhui, Fujian, Jiangxi and Zhejiang Provinces in mainland China with corolla tubes 2–5mm long and corolla lobes 6–8mm long. From these data the Chinese plants belong to *C. ramondioides* var. *taiwanensis*.

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