

The genus *Barbarea* (Brassicaceae) in Taiwan

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(Received December 10, 1999; Accepted February 11, 2000)

Abstract. *Barbarea* R. Brown consists of about 20 species distributed mainly in Europe and Asia, with the native range of one, *B. orthoceras* Ledeb., extending from central and eastern Asia into North America. In eastern Asia *Barbarea* is represented by two native species, *B. taiwaniana* and *B. orthoceras*, both of which occur in Taiwan. The taxonomy of the Taiwanese species, however, has been the subject of continuous controversy and there are drastically conflicting views as to their limits. The principal reason behind this persistent controversy is a result of the misinterpretation of the limits of two species, one described by Hayata (1913) as *Cardamine arisanensis* Hayata and the other by Ohwi (1934) as *Barbarea taiwaniana* Ohwi, by various authors without the examination of type material. We have critically examined all types cited in this paper, and clarified the confusion in the taxonomy of Taiwanese *Barbarea*. A detailed description of the genus and its species in Taiwan are provided. A key to the species of *Barbarea* in Taiwan, synonymies, notes on their distribution with maps, and photographs of representative specimens are presented.

Keywords: *Barbarea*; *Barbarea derchiense*; *Barbarea orthoceras*; *Barbarea taiwaniana*; Brassicaceae; Cruciferae; Distribution; Taiwan; Taxonomy.

Barbarea R. Brown consists of about 20 species distributed mainly in Europe and Asia (Al-Shehbaz, 1988), with the native range of one, *B. orthoceras* Ledeb., extending from central and eastern Asia into North America (Rollins, 1993). The center of greatest diversity is Turkey and the Balkan Peninsula, where 11 of the 17 species are endemic (Ball, 1993; Coode and Cullen, 1965; Greuter et al., 1986; Tan and Gemici, 1990). Hewson (1982) listed two species as endemic to Australia, but as indicated by Al-Shehbaz (1988) both are somewhat anomalous in *Barbarea* because of their annual habit and tuberculate, margined or winged seeds.

Barbarea is represented in eastern Asia by two native species, one of which is endemic to Taiwan. The taxonomy of the Taiwanese taxa has been the subject of continuous controversy, however, and there are drastically conflicting views as to their delimitation. Perhaps the principal reason behind this persistent controversy is a result of the fact that the limits of two species, one described by Hayata (1913) as *Cardamine arisanensis* Hayata and the other by Ohwi (1934) as *Barbarea taiwaniana* Ohwi, were misinterpreted by various authors without examination of type material. Two of the most recent accounts of the Taiwanese *Barbarea*, Shen (1996) and Ying (1996) are completely contradictory (see below) and do not provide accurate descriptions of the taxa. A critical re-examination of the problem is therefore necessary. We have examined all types cited in this paper, and we are confident that we have resolved the problems in Taiwanese

Barbarea. A detailed description of the genus based on all of its species worldwide and detailed descriptions of the Taiwanese species are provided.

In his original description of *Cardamine arisanensis*, Hayata (1913) provided a detailed description and illustrations of the entire plant and cited two syntypes, both of which are deposited at TI and which we critically examined. Hayata did not realize, however, that he was dealing with two species in two different genera. Both syntypes were annotated by Hayata as *Cardamine arisanensis* Hayata. One syntype, Kawakami & Mori 2252, is a species of *Barbarea* and consists of a caudex, fragmentary stem, and a few basal leaves, one of which was illustrated accurately in the figure accompanying the original description. For the second syntype, Hayata (1913) wrote only "montibus centralibus, Feb. 1908" in the protologue. The label on the syntype indicates, however, that the plant was collected by Kawakami and Mori (# 3631) on 25 March 1908 (not February) from Ali Shan. Schulz (1903) identified this syntype as *Cardamine flexuosa* With. subsp. *fallax* O. E. Schulz. Hayata's (1913) descriptions and illustrations of the cauline leaves, flowers, fruits, and seeds of *Cardamine arisanensis* were accurately taken from this syntype.

Ohwi (1934) was the first to realize that Hayata (1913) included two species in his original description of *Cardamine arisanensis*. By listing "*Cardamine arisanensis* Hayata, Icon. Pl. Formosan. 3 (1913) 20 ex pte., quoad folia" under his original description of *B. taiwaniana*, Ohwi thereby effectively lectotypified *C. arisanensis* (lectotype, Kawakami & Mori 3631, TI) and

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removed the *Barbarea* element to his new species. Unfortunately, many workers who dealt with *Barbarea* in Taiwan (e.g. Liu and Ying 1976; Ying, 1978, 1996; Guo, 1987; Lin, 1993, 1999; Chen, 1998) overlooked this fact, and wrongly interpreted the limits of *B. taiwaniana* to include what is known elsewhere as *B. orthoceras*. These authors also mistakenly named the endemic species of *Barbarea* from Taiwan *Cardamine arisanensis* or *B. arisanensis* (Hayata) S. S. Ying. In recent publications on Taiwanese Brassicaceae, only Lu (1977), Shen (1996) and Yang et al. (1997) provided the correct names for the two Taiwanese species of *Barbarea*. They recognized *B. orthoceras* var. *formosana* Kitam. as endemic to Taiwan, however, when in fact this variety is indistinguishable from plants of the highly variable *B. orthoceras* from other parts of the world. This variety therefore does not merit recognition.

Ying (1995) described *Barbarea derchiense* S.S. Ying from Taichung Hsien. We have not seen the type, but the detailed description and colored photos clearly indicate that it is not a *Barbarea*. It is very likely that this species is *Brassica rapa* L. (including *B. campestris* L.) because of its entire amplexicaul cauline leaves, rounded (probably misdescribed for globose) seeds, yellow flowers overtopping the flower buds, lyrate basal leaves, and fruits and pedicels to 5 cm long. Cabbages, turnips, cauliflower, and other crops of various species of *Brassica* are grown in Taiwan, and some are likely to have escaped from cultivation. Liu and Ying (1976), Ying (1996), and Shen (1996) did not mention the genus in their accounts.

Taxonomic Treatment

BARBAREA R. Brown in W. T. Aiton, Hortus Kew. ed. 2. 4: 109. 1812, nom. cons. — Type species: *B. vulgaris* R. Brown

Herbs biennial or perennial with rhizomes or woody caudex, rarely annuals. Trichomes absent or present and unicellular, eglandular, simple. Roots forming a taproot system, sometimes adventitious from lower nodes. Stems erect to ascending, sometimes prostrate, angular, simple or branched basally and/or apically. Basal leaves petiolate, fleshy or not, forming or not forming a rosette, lyrate-pinnatifid or pinnatisect, rarely undivided; terminal lobes larger or rarely subequalling neighboring lateral lobes. Cauline leaves petiolate or sessile, auriculate or amplexicaul at base, entire, dentate, pinnatifid, or pinnatisect, glabrous or basally ciliate. Inflorescences many-flowered, usually dense, ebracteate or very rarely bracteate, terminal, corymbose racemes, elongated slightly or considerably in fruit; rachis straight, or rarely slightly flexuous, striate; bracts when present restricted to lowermost flowers. Fruiting pedicels slender or thickened and nearly as wide as fruit, terete or angled, erect and appressed to rachis, ascending, or divaricate. Sepals oblong to linear, free, deciduous, erect, ascending, or spreading, glabrous or subapically pubescent, somewhat unequal, base of inner pair saccate, margin membranaceous or not. Petals bright to pale yellow, rarely creamy white, erect at base with flaring blade, longer or rarely nearly as long as sepals; blade spatulate

to oblanceolate, apex obtuse to rounded, margin entire; claw short and sometimes obscurely differentiated from blade, glabrous, unappendaged, entire. Stamens 6, only slightly exserted, erect, tetradynamous; filaments filiform, wingless, unappendaged, not dilated at base, glabrous, free; anthers oblong, rounded to sagittate at base, obtuse at apex, not coiled after dehiscence. Pollen tricolpate. Nectar glands 4, median pair toothlike or rod shaped; lateral nectaries semiannular, or annular. Ovules 10-40 per ovary; placentation parietal. Fruit dehiscent, capsular siliques linear or rarely elliptic-linear, terete, 4-angled, or slightly to strongly flattened and latiseptate, appressed to rachis or not, not inflated, sessile or short stipitate, unsegmented; valves papery or leathery, with a prominent midvein and sometimes with obscure or distinct reticulate lateral veins, glabrous or rarely hairy, rounded or rarely keeled, smooth or distinctly torulose, wingless, unappendaged; gynophore to 1 mm long; replum rounded; septum complete, membranous or thickened and papery, sometimes with a distinct midvein; style obsolete, short, or up to 5 mm long, stout to slender, cylindric to subconical, persistent, glabrous; stigma capitate, entire or slightly 2-lobed and lobes free. Seeds 6-20 per locule, uniseriate or subbiseriate, wingless or narrowly winged or margined, oblong, ovoid, or orbicular, plump or slightly flattened; seed coat minutely to coarsely reticulate, rarely tuberculate, not mucilaginous when wetted; cotyledons accumbent, entire.

Key to the Species of *Barbarea* in Taiwan

- 1a. Terminal leaf lobe much larger than neighboring lateral lobes; cauline leaves usually lyrate-pinnatifid, with 1-4 lateral lobes; fruit terete-subquadrangular, 1.2-1.5 mm wide; seeds plump, wingless 1. *B. orthoceras*
- 1b. Terminal leaf lobe about the same size as neighboring lateral lobes; cauline leaves pinnatisect, with (4-)6-10 (-12) lateral lobes; fruit compressed, (1.5-)2-2.5 mm wide; seeds compressed, winged 2. *B. taiwaniana*

1. *Barbarea orthoceras* Ledeb., Index Semin. Hort. Dorpat 1824.—TYPE: Russia, Baikal, between mouths of Barguzin and Upper Angara rivers, *Ledebour s.n.* (holotype, LE). 山芥菜 Figure 1

Barbarea orthoceras Ledeb. var. *formosana* Kitam., Coloured Ill. Herb. Pl. Jap. 2: 179. 1963; Lu, Quart. J. Chin. Forest. 10(3): 97, photo 10. 1977; Shen, J. Exp. Forest, Natl. Chungshing Univ. 18: 12, fig. 7. 1996; Yang, Liu & Lu, Manual Taiwan Vasc. Pl. 2: 211, photo 535.

Barbarea taiwaniana auct. non Ohwi: Ying, Alpine Pl. Taiwan Color I: 56, photo 54. 1975, Alpine Pl. Taiwan 72, photo 51. 1980; Liu & Ying, Fl. Taiwan 2: 679, pl. 446. 1976; Hsu et al., Alpine Pl. Taiwan 54. 1986; Guo, Fl. Reipubl. Popularis Sin. 33: 248, pl. 65:7. 1987; Lin, Ill. Guide to Taiwan Alpine Pl. 6. 1993, Wild Fl. Taiwan (High elevation) 64. 1999; Chen, Veg. Taiwan 2(2): 450-451. 1997.

Herbs biennial or perennial. Stems (10-)20-60(-100) cm tall, erect, angled, glabrous throughout. Basal and lowermost cauline leaves petiolate; petiole (0.5-)1-5(-7) cm long, glabrous or rarely ciliate basally; leaf blade (1-)1.5-4(-6) cm long, lyrate-pinnatifid, with (1 or)2-4(-6) lobes on each side of rachis, rarely unlobed, not fleshy; lateral lobes oblong to ovate, $2-10 \times 1-5$ mm, entire; terminal lobe considerably larger than lateral ones, $1.5-5 \times 1-2.5$ cm. Cauline leaves usually lyrate-pinnatifid, with 1-4 lateral lobes, rarely coarsely toothed, sessile, conspicuously auriculate; auricles ovate to narrowly oblong, to 8×5 mm, ciliate, entire; lateral lobes oblong to ovate, rarely lanceolate, to 2×1 cm, glabrous, entire; terminal lobe much larger than lateral lobes and to 5×3 cm, entire or repand to rarely dentate.

Racemes ebracteate, elongated considerably in fruit. Sepals yellow, oblong, $2.5-3.5 \times 1-1.5$ mm, erect, margin scarious, lateral pair slightly saccate. Petals yellow or pale yellow, oblanceolate, rounded, $(3-4-5(-6) \times 1.5-2$ mm, attenuate to base. Filaments yellow, erect, 3-4.5 mm long; anthers oblong, ca. 1 mm long. Fruiting pedicels erect to ascending, (2-)3-6(-7) mm long, terete to subquadrangular, glabrous, stout, slightly narrower than fruit. Fruit linear, (1.5-)2-4(-5) cm \times 1.2-1.5 mm, terete-subquadrangular, torulose, erect to erect-ascending; gynophore to 0.3 mm; valves with a prominent midrib and lateral veins; style 0.5-1(-1.2) mm long. Seeds brown, ovate to oblong, 1.2-1.5 \times 0.9-1 mm, uniseriate, somewhat plump, wingless. Flowering June-July; fruiting August-September.



中央研究院植物研究所標本館 (HAST)
BOTANICAL INVENTORY OF TAIWAN

BRASSICACEAE 十字花科
Barbarea orthoceras Ledeb. 山芥菜
Det. by Ching-I Peng (彭鏡毅)

NANTOU HSIEN (南投縣), Jenai Hsiang (仁愛鄉),
Taroko National Park (太魯閣國家公園), Hohuanshan
Military Skiing Training Center (合歡山寒訓中心).
121°16'22"E, 24°08'42"N Elev. ca. 3100 m
Taiwan Grid: 277754 E, 2671145 N

Grassy field on saddle.

Herb. At peak anthesis, flowers yellow.
In grassy field, exposed, frequent.

Ching-I Peng (彭鏡毅) 17360 June 16, 1999

with 鍾國芳, A. Anderberg, 陳復清

Duplicates: S, MO, OOH, OSH, SAPA

HERBARIUM, INSTITUTE OF BOTANY, ACADEMIA SINICA, TAIPEI (HAST)

Figure 1. *Barbarea orthoceras* Ledeb. Photograph of Peng 17360 (HAST) from Taiwan.

Additional specimens examined. **TAIWAN.** TAICHUNG HSIEN: Nanhutashan, Shimada 1408 (TAI), Huang 7817 (TAI), 3,400-3,500 m, Wang 864 (TNM), ca. 3,500 m, Yamazaki et al. 441 (TAI); Hoping, Kenankuan, Wang 2778 (HAST, TNM). NANTOU HSIEN: Jenai, Sunghsuehlo to Tsuifeng, Yang 2219 (TNM), Sunghsuehlow, 31 July 1992, Wang s.n. (TNM), Hohuanshan Military Skiing Training Center, Peng et al. 17360 (HAST, MO, OOM, OSH, S, SAPA,), Tienchih to Nengkaopeifeng, Chiu et al. 3422 (HAST, TNM), Piluhsi, Lu & Ou 3544 (TAI). CHIAYI HSIEN: Alishan, Kawakami & Mori 10973 (TAIF). HUALIEN HSIEN: Hohuanshan, Kao 7759 (TAI), ca. 3,200 m, Hsieh 950 (TAI), Ou & Kao 9163 (TAI); Nengkaoyueh (Nokogoe), Ohwi 3189 (TNS); Tayuling, ca. 2,565 m, Lai & Liang 13262 (A).

Distribution and Notes. Eastern and central Asia, North America. In Taiwan in the *Tsuga-Picea* zone, *Abies* zone or in open grasslands, and on scree, often in moist or wet areas, 2,500-3,500 m (Figure 2).

2. *Barbarea taiwaniana* Ohwi, Repert. Spec. Nov. Regni Veg. 36: 50. 1934; Masamune, List Vasc. Pl. Taiwan 56. 1954; Lu, Quart. J. Chin. Forest. 10(3): 98, photo 11. 1977; Shen, J. Exp. Forest Natl. Chungsing Univ. 18: 13, fig. 8. 1996; Yang, Liu & Lu, Manual Taiwan Vasc. Pl. 2: 212, photo 536. 1997.— TYPE: Formosa, Mt. Niitaka, July 1933, Jisaburo Ohwi 3677 [holotype, KYO (photo, TNS!); isotype, TNS!]. 台灣山芥菜 Figure 3
Cardamine arisanensis Hayata, Icon. Pl. Formosan. 3: 20, ex parte, quoad folia.

Cardamine arisanensis auct. non Hayata: Ying, Alpine Pl. Taiwan Color 1: 56, photo 55. 1975; Liu & Ying, Fl. Taiwan 2: 683. 1976; Cheo, Fl. Reipul. Popularis Sin. 33: 206. 1987.

Barbarea arisanensis (Hayata) S. S. Ying, Alpine Pl. Taiwan Color 2: 170. 1977, Alpine Pl. Taiwan 72, photo 50. 1980, Fl. Taiwan 2nd ed. 2: 749, photo 333, 1996; Hsu et al., Alpine Pl. Taiwan 53. 1986; Lin, Ill. Guide Taiwan Alpine Pl. 4, 1993, Wild Fl. Taiwan (High elevation) 63. 1999; Chen, Veg. Taiwan 2(2): 450-451. 1997.

Herbs perennial. Caudex apically branched or simple in younger plants, often with petiolar remains of previous years. Stems (6-)10-20(-35) cm tall, erect or rarely decumbent when many branched from base, angled, glabrous throughout. Basal and lowermost cauline leaves petiolate; petiole (2-)3-7(-10) cm long, ciliate at least basally, grooved adaxially; leaf blade (2-)3-5(-9) cm long, pinnatisect, with (3-)5-8(-10) lobes on each side of rachis, somewhat fleshy; lateral lobes oblong to ovate, (2-)5-10(-15) × (1-)3-6(-10) mm, entire or obtusely lobed; terminal lobe about as large as lateral ones. Cauline leaves pinnatisect, with (4-)6-10 (-12) lateral lobes, petiolate, reduced in size and sessile upward, conspicuously auriculate; auricles ovate to oblong, to 12 × 5 mm, ciliate, base rounded, entire or rarely toothed; lateral lobes linear to narrowly oblanceolate or oblong, rarely ovate, to 15 × 5 mm, glabrous, entire or usually lobed or obtusely toothed on proximal margin; ter-

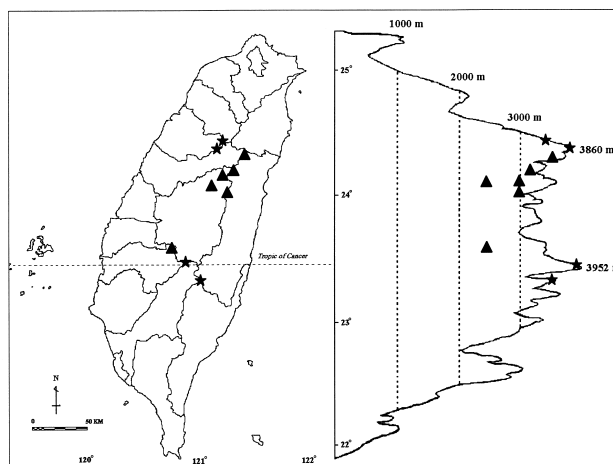


Figure 2. Latitudinal and altitudinal distribution maps of *Barbarea orthoceras* (triangles) and *Barbarea taiwaniana* (stars) in Taiwan.

minial lobe about as large as neighboring lateral lobes, mostly 3-lobed. Racemes ebracteate, slightly elongated in fruit. Sepals yellowish, usually tinged purple at middle, oblong, 3-4 × 1-1.5 mm, erect, margin scarious, lateral pair slightly saccate. Petals yellow, oblanceolate, rounded, 5-7 × 2-2.5 mm, attenuate to base. Filaments yellow, erect, 3-4 mm long; anthers oblong, ca. 1 mm long. Fruiting pedicels erect-ascending, 3-6(-10) mm long, angled to subterete, glabrous. Fruit linear, (1-)1.5-2.5 cm × (1.5-)2-2.5 mm, compressed, somewhat torulose, erect to erect-ascending, somewhat appressed to rachis; gynophore 0.2-0.5 mm; valves with a prominent midrib; style 0.5-2 mm long. Seeds yellowish brown, ovate to suborbicular, 1.5-2 × ca. 1 mm, uniseriate to subbiseriate, somewhat compressed, often winged all around, wing to 0.2 mm wide. Flowering June-July, fruiting August-September.

Additional specimens examined. **TAIWAN.** HSINCHU HSIEN: Tapachienshan, 20 Jul 1932, Sasaki s.n. (TAI). TAICHUNG HSIEN: Hsuehshan ("Mt. Tugitaka"), Masamune & Susuki 5317 (TAI), Suzuki 5318 (TAI), Aug 1924, Ohashi s.n. (TAIF), Ohashi 28499 (TAIF), Ying 3845, 3894, 3914, 3913, 3915 (all at NTUF), Shu 17 (NTUF), Chiu 1992 (TNM), 3,500-3,884 m, 23 Aug 1995, K. C. Yang s.n. (TAIF), en route from 369-Shanchuang (a lodge) to Hsuehshan peak, 24 Oct 1947, Mori s.n. (TAI), ca. 3,600 m, Hsu & Moore 747 (A, HAST), Yang 5632, 6169 (both at TNM), 369-Shanchuang to Tsueichih, Wang, Huang & Tang 4424 (TAI). NANTOU HSIEN: Yushan National Park, Paiyun Lodge to Yushan main peak, Peng et al. 14384 (HAST, TAIF, TNM), Lu 14799 (TAIF), Paiyun Lodge to Yuanfeng Lodge, Cheng 2327 (TAIF). CHIAYI HSIEN: Yushan ("Mt. Niitaka", "Mt. Morrison"), Kawakami & Mori 2252 (TI), ca. 3,900 m, Hsu 5354 (TAI), Suzuki 13349 (TAI), 3,800-3,900 m, 6 Sep 1960, Kuoh & Tu s.n. (TAI), Chuang 2912 (TAI), Chuang, Kou & Kao 4006 (HAST), Kawakami & Mori 10972 (TAIF), Y. & F. Yamazaki 811 (TI), Ying 1430, 1955, 1975 (all at NTUF), en route from



Figure 3. *Barbarea taiwaniana* Ohwi. Photograph of Peng 9549 (HAST) from Taiwan.

Paiyun Lodge to peak, 3,500-3,997 m, *Hsu* 6274 (TAI), *Peng* 9549, 14384 (both at HAST), ca. 3,528-3,950 m, *Leu* 229, 242 (both at HAST), *Lu & Ou* 3683 (NCUF), en route from Haiunsano to the top of Yushan, *Koyama* 23900 (TNS), route from summit to Tataka, *Tamura, Shimizu & Kao* 22134 (TNS), Monroe ("Moroo") Cliff to Tungpu, *Hsu* 5350 (TAI). TAITUNG HSIEN: Hsiangyangshan, 3,494-3,600 m, *Chiu et al.* 2909 (HAST, TNM).

Distribution and Notes. Endemic; under *Abies*, in sunny, rocky areas, above timberline, and in rock crevices; 3,200-3,950 m (Figure 2).

Acknowledgments. We are grateful to Hideaki Ohba (TI) and Shinobu Akiyama (TNS) for the loan of types. We thank Henk van der Werff (MO) for useful comments, Sachiko Nishida (KYO) for the translation of Japanese and Kuo-Fang Chung (HAST) for technical assistance.

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台灣山芥菜屬植物（十字花科）之分類訂正

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山芥菜屬 (*Barbarea* R. Brown) 約含 20 種植物，主要分布於歐亞兩洲，其中山芥菜 (*B. orthoceras* Ledeb.) 廣泛分布於亞洲中部、東部及北美洲。在東亞共有兩種山芥菜屬植物，山芥菜 (*B. orthoceras* Ledeb.) 及台灣山芥菜 (*B. taiwaniana* Ohwi)，它們都產於台灣。但歷來台灣產的山芥菜屬植物之分類十分混亂，主要因為許多學者並未檢視 Ohwi 1934 年發表的 *Barbarea taiwaniana* Ohwi 及 Hayata 1913 年發表的 *Cardamine arisanensis* Hayata 的模式標本，而導致誤判，使用了錯誤的學名。作者詳加研閱相關植物的模式標本，澄清了台灣自生山芥菜屬植物的混亂學名，對台灣產的山芥菜屬、種之分類性狀詳加描述，並提供種的簡索表，臚列異名、分布圖、及兩種植物標本的照片，以資辨識。

關鍵詞：山芥菜屬；山芥菜；台灣山芥菜；十字花科；分布；台灣；分類。