植物分类学报 41(4): 305-349 (2003)
Acta Phytotaxonomica Sinica

Delimitation and revision of *Hilliella* and *Yinshania* (Brassicaceae)

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Abstract Taxonomic characters for delimitation of *Hilliella* and *Yinshania* are discussed. More attention in this study is paid to morphological delimitation of these two genera. The results of the study show that these two genera can be easily separated by two primary morphological features of their fruits and seeds: *Hilliella* has eseptate fruits and tuberculate seeds while *Yinshania* has septate fruits and reticulate seeds. In addition, these two genera also differ in morphology of their leaves, trichomes, sizes of seeds, and their geographical distributions and ecological adaptations as well. Furthermore, both of them have different numbers and ploidy levels of chromosomes. Therefore, *Hilliella* and *Yinshania* are retained as two genera in this paper, as was suggested by the previous studies. *Hilliella* includes 11 species, four varieties. *H. longistyla* Y. H. Zhang, *H. lichuanensis* Y. H. Zhang and *H. guangdongensis* Y. H. Zhang are relegated to varieties of *H. changhuaensis* Y. H. Zhang. *Yinshania* remains in two sections: sect. *Yinshania* and sect. *Microcarpa* Y. H. Zhang including eight species and two varieties. A new combination is proposed: *Y. acutangula* (O. E. Schulz) Y. H. Zhang var. *gobica* (Z. X. An) Y. H. Zhang. Descriptions, distributions and keys to the infrageneric subdivisions are provided. Errors and confusions in the previous studies on taxonomy of *Hilliella* and *Yinshania* are also discussed and redressed.
Key words Brassicaceae, *Hilliella*, *Yinshania*, taxonomy.

Hilliella (O. E. Schulz) Y. H. Zhang & H. W. Li and *Yinshania* Y. C. Ma & Y. Z. Zhao were both separated from *Cochlearia* L. s. l. *Hilliella* was established by raising sect. *Hilliella* O. E. Schulz to generic rank by Zhang & Li (Zhang, 1986). *Yinshania* was described as a new genus by Ma & Zhao (1979) based on *Y. albiflora* Y. C. Ma & Y. Z. Zhao. Since then, the two genera were accepted by Li (1988), Wang (1992), Ying & Zhang (1994) and Wei & Zhou (1998) and a few new species were described (Zhang, 1987a, b, 1993, 1995a, 1997; Li, 1988; An, 1995). However, other taxonomists have different points of view on the delimitation of these two genera. For example, Kuan (1987) placed 13 species belonging to *Hilliella*/*Yinshania* group in *Cochlearia*. Lu (1991) put the majority of *Hilliella* species in *Cochlearia*. Zhao (1992) merged these two genera into one, *Yinshania*. Al-Shehbaz et al. (1998), in particular, reduced *Cochleariella* Y. H. Zhang & R. Vogt and *Hilliella* to synonymy of *Yinshania*. Meanwhile some studies of chromosome number (Tian, 1990; Zhang, 1995c, 1996a; Zhang & Ma, 2001) and features of leaf epidermal cells (Wei & Zhou, 1998) and venations (Zhou & Wei, 2002) have been done. Chemical feature has been known from Ina et al. (1993), though only a little, it is

Received: 2 September 2002 Accepted: 17 June 2003
Supported by the National Natural Science Foundation of China (Grant No. 9390010), Zhejiang Provincial Natural Science Foundation (Grant No. 397069) and International Cooperation Division, Zhejiang Provincial Science and Technology Department (Grant No. 98-2-031).

advantageous for taxonomic study. Koch and Al-Shehbaz (2000) reported molecular phylogenies of the two genera constructed from sequence analysis of nrDNA ITS (internal transcribed spacer regions of nuclear ribosomal DNA) and the cpDNA *trn*L-intron (*trn*L-intron of chloroplast DNA) from 18 taxa. However the results gave no support to the previous work of Al-Shehbaz et al. (1998).

In view of the above-mentioned facts this group of Chinese-endemic Brassicaceae has caused considerable controversy regarding the generic identity indeed. In 2001, the Brassicaceae in Flora of China (Zhou et al., 2001) was published and the chapter on *Yinshania* completely adopted the taxonomic treatment made in the 1998 paper by Al-Shehbaz et al. I agree that *Cochleariella* could be united with *Hilliella* and recognise some of the errors they pointed out in my previous work. But I have not been convinced that *Hilliella* and *Yinshania* should be recognized as a single genus of *Yinshania* sensu Al-Shehbaz et al. based on my many years' work on this group of plants. I therefore reexamined more carefully all the collections that I could and the results of the reexamination are presented in this paper to reiterate why and how they should be delimited as two genera of *Hilliella* and *Yinshania* rather than just one. Errors and confusions in the previous studies on taxonomy of *Hilliella* and *Yinshania* are also discussed and redressed. Because the taxonomic treatment of *Yinshania* in the Flora of China is the same as that made in the paper by Al-Shehbaz et al. (1998), it has not been cited in the taxonomic treatment in this paper.

1 Material and methods

Herbarium specimens used in this study were examined. They were from the following herbaria: A, ANUB, B, BJTC, BM, CDBI, E, FNU, HAST, HHBG, HIB, HIMC, HNNU, HZU, IBSC, K, KUN, LBG, LE, MO, NAS, NY, P, PE, SG, SHCT, SHM, SM, SRMC, SZ, TAI, TI, TNS, US, W, WU, WUK, ZJFC, ZJMA, and ZM. Two holotypes kept at HK and one isotype kept at GH were only available as photographs. All other specimens were examined directly. Some specimens were collected in recent years from different geographical regions and from different populations in the same region, or from the same population in different seasons. These have been deposited in the herbaria of HHBG, HZU, ZJMA and ZM.

For SEM observation of seed-coat microcharacters and trichomes, seeds, leaves or stem were directly mounted on metal stubs using plastic conductive carbon cement and sputter-coated with gold. Observation was carried out using a KYKY-1000B (Beijing) scanning electron microscope at an accelerating voltage of 20 kV.

Details of vouchers were noted in Table 1. Several important characters of septa and leaves were illustrated with line drawings.

2 Results and character analysis

2.1 Septum

The septum is an important attribute of the fruit in Brassicaceae. The ovary in the Brassicaceae is divided into two chambers by a thin, unvasculated partition or septum connecting the two parietal

Table 1 Origin of material for SEM observation of seed-coat microcharacters and trichomes

Taxon	Locality	Voucher
Hilliella		
H. changhuaensis Y. H. Zhang var. *changhuaensis*	Huangshan, Anhui	S. X. Wang 95001, ZJMA
H. changhuaensis Y. H. Zhang var. *lichuanensis*	Taihe, Jiangxi	S. S. Lai 592, LBG
H. changhuaensis Y. H. Zhang var. *longistyla*	Longquan, Zhejiang	H. H. Hu s. n. Jun. 1919, ZM
H. yixianensis Y. H. Zhang	Yi Xian, Anhui	Y. H. Zhang 93012, ZJMA
H. paradoxa (Hance) Y. H. Zhang & H. W. Li	Chongqing, Sichuan	S. F. Wu & Z. G. Cai 9221, ZJMA
Yinshania		
Y. furcatopilosa (Kuan) Y. H. Zhang	Shennongjia, Hubei	Y. Zhou 9107001, ZJMA
Y. exiensis Y. H. Zhang	Yichang, Hubei	Z. Zheng 1473, HIB
Y. zayüensis Y. H. Zhang	Zayü, Xizang	C. W. Wang 65236, WUK
Y. qianningensis Y. H. Zhang var. *qianningensis*	Kangding, Sichuan	S. F. Wu & Z. G. Cai 9378, ZJMA

placentas (Cronquist, 1981). Septa that arise as outgrowths of the inner surface or at sutures of the carpels, as in the Cruciferae (Brassicaceae), are called false septa (Fitting et al., 6th English ed., 1930) to distinguish them from true septa which are formed by fusion of carpel walls.

Since Prantl (1891) employed the term septum in the classification of Brassicaceae (Cruciferae), it has been regarded as important by many taxonomists. Several characters of the septum, whether complete or incomplete or absent, narrow or broad, at right angles to the plane of compression (angustiseptate) or parallel with the plane of compression (latiseptate) of the fruit, epidermal cells of the septum parallel with axis or not are usually used in keys to tribes and genera in the Brassicaceae (Hewson, 1982; Clapham, 1987; Webb et al., 1988; Stace, 1991; Entwisle, 1996). *Hilliella* has no septum (Fig. 1: A, B, C) while *Yinshania* has a septum (Fig. 1: D, E, F), complete or incomplete with holes (Fig. 1: F). It is undoubtedly logical that presence or absence of septa becomes one of the most important morphological characters to separate *Hilliella* and *Yinshania*.

2.2 Seed

In the Brassicaceae, macroscopic and microscopic characters of seeds are important for the delimitation of genera and species, and understanding their relationships. As noted by Davis and

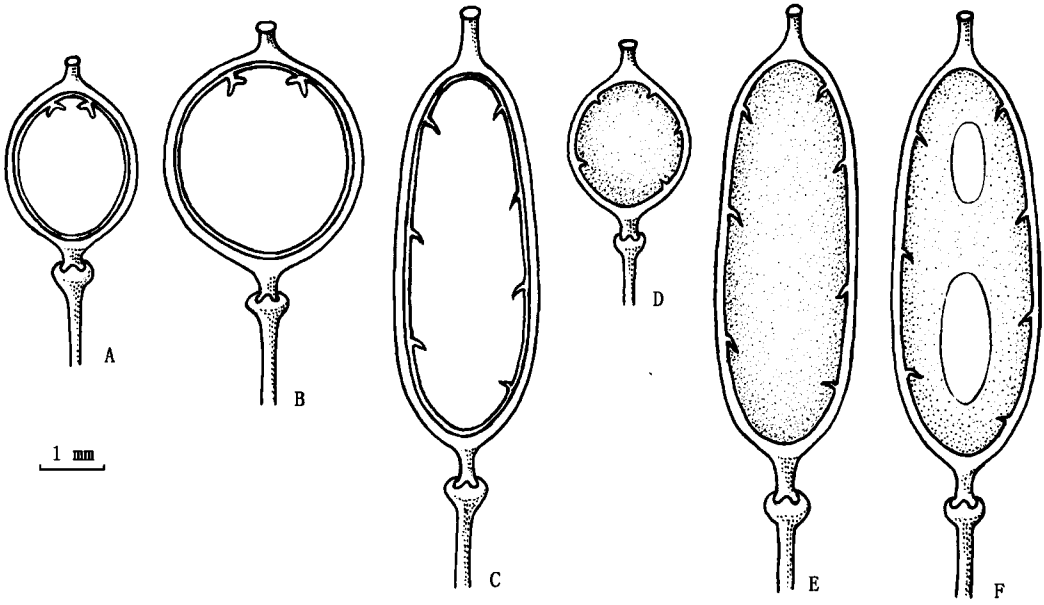

Fig. 1. Replums of *Hilliella* and *Yinshania*, showing *Hilliella* having no septa and *Yinshania* having the septa. A, *H. warburgii* (Z. Z. Zheng 7147, HZU); B, *H. hunanensis* (Z. Z. Zheng s. n. May 1977, HZU); C, *H. rivulorum* (X. Y. He 21828, HHBG); D, *Y. microcarpa* (Gulin Exped. 943, PE); E, F, *Y. acutangula* (Y. Z. Zhao s. n. Aug. 1991, ZJMA). Bar = 1 mm.

Heywood (1963) that: "In the Cruciferae great reliance is placed on seed characters, together with features of the fruit, nectaries and type of hairs in the indumentum, for generic and tribal divisions." The seeds of *Hilliella* are larger (1 – 2.5 × 0.8 – 1.5 mm) than those of *Yinshania* (0.5 – 1 × 0.5 – 0.8 mm). *Hilliella* has a tuberculate seed-coat (Fig. 2: A – F) and each tubercle has a smooth surface or is concave on the top. In contrast, *Yinshania* has a reticulate seed-coat (Fig. 2: G – J), and the reticulations are of varying mesh sizes. The meshes are oblong, elliptical or irregular and each big mesh is divided into many smaller meshes. Sometimes there are tiny projections in each small mesh. It is apparent that *Hilliella* differs from *Yinshania* with regard to seeds not only macroscopically (seed sizes) but also microscopically (seed-coat ornamentations). Such clear differences in seed morphology strongly support their separation into two genera.

Zhang and Cai (1989) illustrated some abnormal seeds of *H. changhuaensis* Y. H. Zhang which had thinner and irregularly reticulate coats, rather than tuberculate seed-coats, which are the normal condition for seeds of this species. This misjudged illustration was not redressed until more normal seeds were collected in Huangshan of Anhui (S. X. Wang 95001). Unfortunately, this misjudged illustration was quoted by Zhao (1992), and Al-Shehbaz et al. (1998), in particular, used

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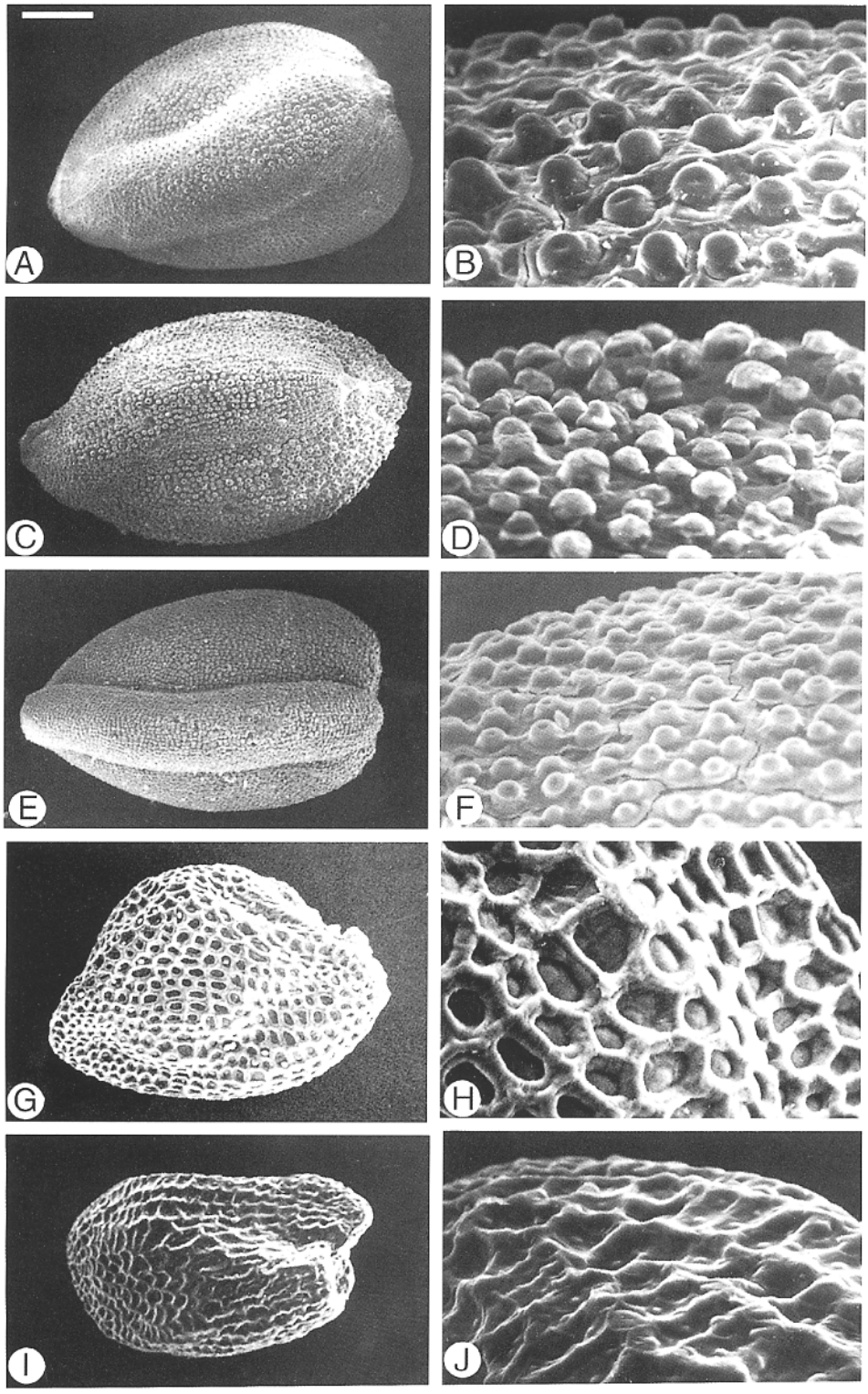
Fig. 2. SEM of seed coats of *Hilliella* and *Yinshania*. **A, B,** *H. changhuaensis* var. *changhuaensis* (S. X. Wang 95001, ZJMA). **C, D,** *H. paradoxa* (S. F. Wu & Z. G. Cai 9221, ZJMA). **E, F,** *H. yixianensis* (Y. H. Zhang 93012, ZJMA). **G, H,** *Y. furcatopilosa* (Y. Zhou 9107001, ZJMA). **I, J,** *Y. qianningensis* var. *qianningensis* (S. F. Wu & Z. G. Cai 9378, ZJMA). Bars: A, C, E, = 0.4 mm; G, I, = 0.18 mm; B, D, F, J, = 40 μm; H, = 44.44 μm.


A
B
C
D
E
F
G
H
I
J

it as one of the reasons for combining *Hilliella* and *Yinshania* into one genus. It is hardly believable that after they examined "a large number of specimens of the complex" all the seeds of the following species were described having "reticulate" seed coats: *H. lichuanensis* Y. H. Zhang, *H. changhuaensis*, *H. longistyla* Y. H. Zhang and *H. guangdongensis* Y. H. Zhang (Al-Shehbaz et al., 1998). In fact, all the seeds of the above four species have a tuberculate seed-coat. The seed-coat ornamentation of *Y. furcatopilosa* (Kuan) Y. H. Zhang was described as "finely papillate" in the same paper, and in this case it should be reticulate.

2.3 Leaf

All of the species of *Hilliella* except *H. sinuata* (Kuan) Y. H. Zhang & H. W. Li have compound leaves with 3 or 3 – 5(– 9) leaflets. The leaf lobes and leaflet blades are ovate, elliptical to oblong-lanceolate and the margins sinuate, obtuse or irregularly dentate. The apices of the leaflet blade and leaf lobe are emarginate, obtuse, acuminate to acuminate-caudate, with distinct callous mucros on the vein tips (Fig. 3: A – F), rarely without. Except for *Y. furcatopilosa Yinshania* has simple leaves, predominantly pinnatisect to pinnatipartite. The leaf lobes are usually oblong or obovate-lanceolate, entire or 1 – 2-toothed; the terminal lobes are usually 3-lobed with the mid one entired and the lateral ones dentate or pinnatilobate. The apices of the leaflet blade and leaf lobe are rounded, obtuse to acute, without callous mucros (Fig. 3: H – K).

The leaves of *Hilliella* and *Yinshania* sometimes vary with their places on the plant. For example, *H. fumarioides* (Dunn) Y. H. Zhang (as *Cochleariella zhejiangensis* (Y. H. Zhang) Y. H. Zhang & R. Vogt ex Zhang & Cai) and *H. warburgii* (O. E. Schulz) Y. H. Zhang & H. W. Li have simple basal leaves, which are suborbicular with 3 – 5 (– 7) lobes (Fig. 3: G) whereas the cauline leaves are compound (Fig. 3: G) except the uppermost. *Y. furcatopilosa* has simple rather than compound leaves. The leaves of *Y. microcarpa* (Kuan) Y. H. Zhang and *Y. henryi* (Oliv.) Y. H. Zhang are compound, usually at the middle and lower part of stem, but the upper ones become simple, pinnatipartite or pinnatisect. Sometimes it is hard to distinguish whether the leaf is pinnatisectly simple or pinnately compound in *Yinshania*. These variations may cause confusion in examination of the leaves of these two groups of plants, as has happened in the previous works (Al-Shehbaz et al., 1998).

2.4 Features of leaf epidermal cells and venation

Epidermal cells differ considerably in size, shape and outline in different plants. The shape of the epidermal cells may provide useful confirmatory evidence, if the identity of a plant is already suspected on other grounds (Metcalfe & Chalk, 1957). Wei & Zhou (1998) examined the leaves of 16 species from *Yinshania*, *Hilliella* and related genera with SEM. The results show that *Yinshania* and *Hilliella* are different in the epidermal features. In the majority of *Hilliella* species, the anticlinal walls of the epidermal cells have clear and sinuous ridges, and the external walls have cuticle with various ornamentations, which make the boundaries of epidermal cells indistinct. In *Yinshania* the anticlinal walls of the epidermal cells are mostly sunken and form grooves, and the external walls between these grooves have cuticles thickened in irregular strips, which make the boundaries of the

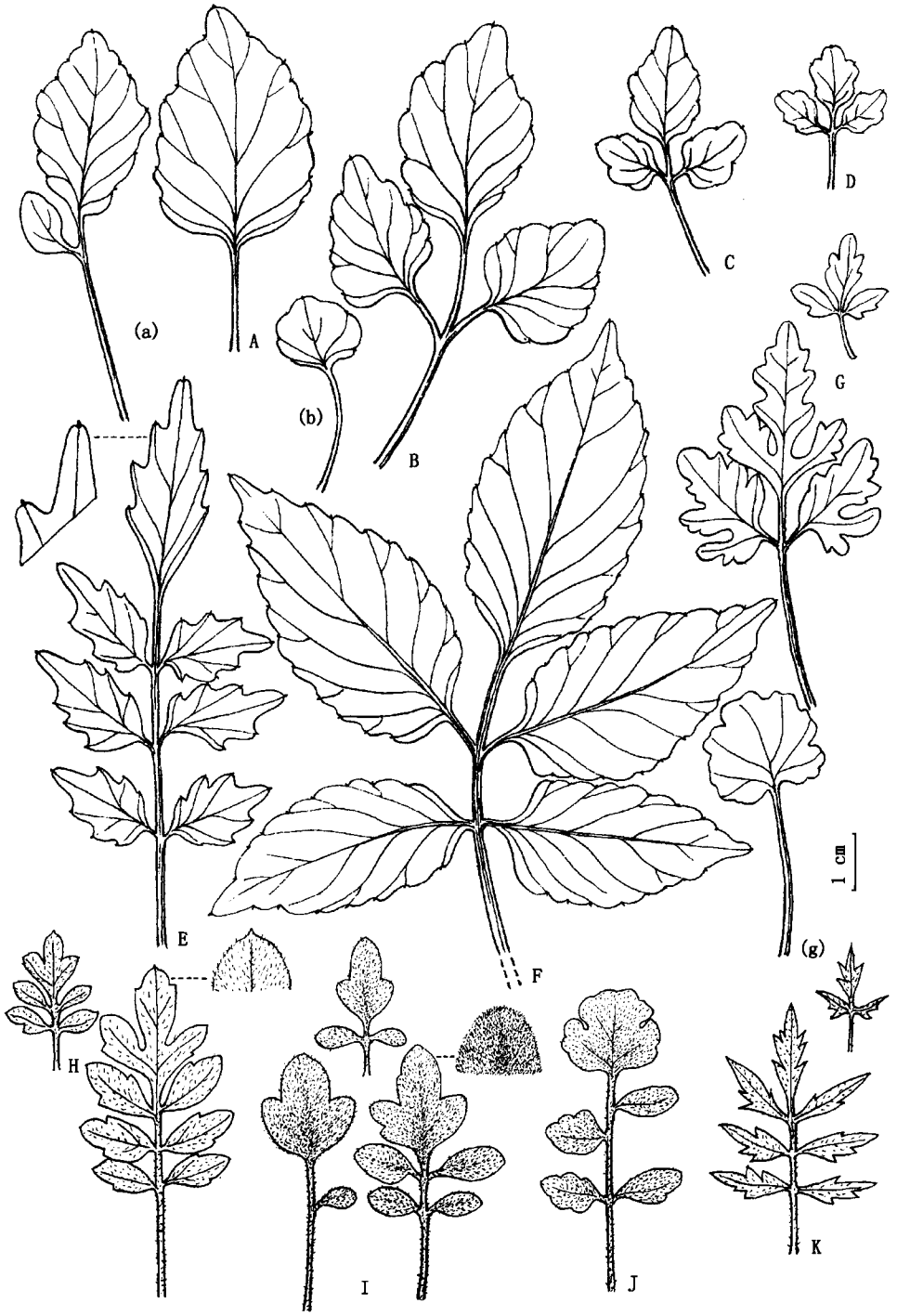


Fig. 3. Cauline leaves and basal leaves (lower-case letters) of *Hilliella* and *Yinshania*. A, *H. sinuata* var. *sinuata* (L. Hong 966, HHBG); B, *H. rivulorum* (X. Y. He 21828, HHBG); C, *H. hui* (G. Y. Li et al. 0656, ZM); D, *H. hunanensis* (Z. Z. Zheng s. n. May 1977, HZU); E, *H. yixianensis* (Y. H. Zhang 95001, ZJMA); F, *H. changhuaensis* var. *changhuaensis* (S. X. Wang 95001, ZJMA); G, *H. warburgii* (Z. Z. Zheng 5572, HZU); H, *Y. acutangula* (Y. Z. Zhao s. n. Aug. 1991, ZJMA); I, *Y. furcatopilosa* (Y. Zhou 9107001, ZJMA); J, *Y. henryi* (Y. Zhou 9107003, ZJMA); K, *Y. qianningensis* var. *qianningensis* (S. F. Wu & Z. G. Cai 9378, ZJMA). Bar = 1 cm.

epidermal cells very distinct.

Zhou & Wei (2002) reported their observation on venation in 16 species of four genera, *Cochlearia*, *Yinshania*, *Hilliella* and *Cochleariella*. The venation of *Cochlearia*, *Hilliella*, and *Yinshania* is brochidodromous, craspedodromous, and half-craspedodromous respectively. *Cochleariella* is similar to *H. warburgii* in leaf venation. The former three genera are different in the size of areole, marginal ultimate venation and shape of apex. They consider it is reasonable to treat *Cochlearia*, *Hilliella* and *Yinshania* as three independant genera.

2.5 Trichomes

There are glandular and non-glandular categories of trichome, each of which may be subdivided according to the number of component cells, degree of branching, and so forth. In Brassicaceae non-glandular trichomes may be simple or branched or even peltate, but they are always unicellular (Metcalfe & Chalk, 1957). In *Yinshania* there are various kinds of trichomes which have been found in different species. For example, *Y. furcatopilosa* has bifurcate trichomes (Zhang, 1987a), *Y. zayüensis* Y. H. Zhang (Fig. 4: A) and *Y. exiensis* Y. H. Zhang (Fig. 4: B) have wide-forked trichomes, and *Y. ganluoensis* Y. H. Zhang has narrower-forked trichomes (Zhang, 1987a). Other species have simple trichomes. For example, *Y. acutangula*, *Y. microcarpa*

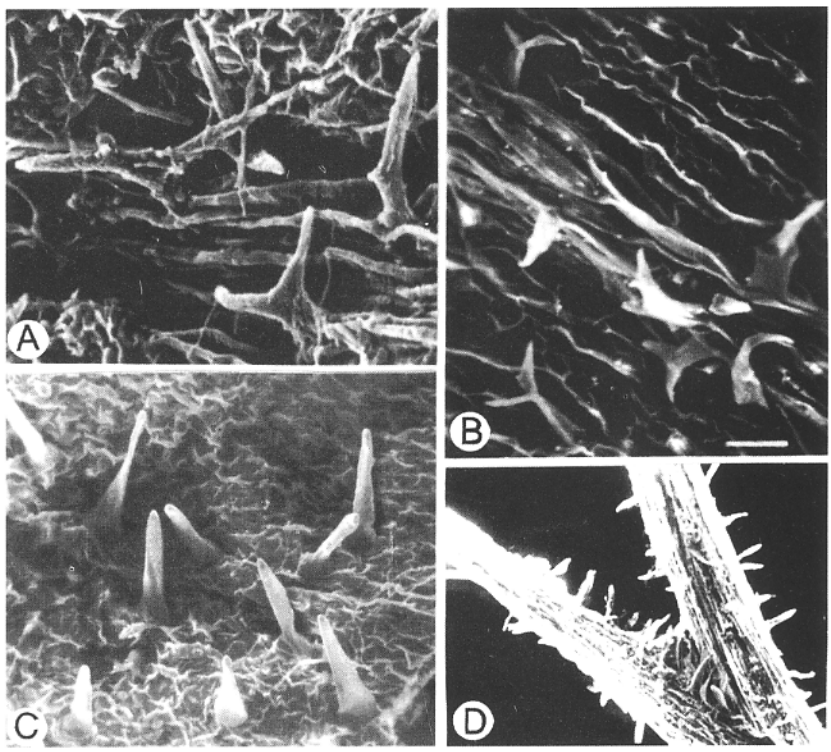


Fig. 4. Trichomes of *Yinshania* and *Hilliella*. **A**, Forked trichomes on leaf of *Y. zayüensis* (C. W. Wang 65236, WUK). **B**, Forked trichomes on leaf of *Y. exiensis* (Z. Zheng 1473, HIB). **C**, Simple trichomes on leaf of *H. changhuaensis* var. *longistyla* (H. H. Hu s. n. Jun. 1919, ZM). **D**, Simple trichomes on stem and branch of *H. changhuaensis* var. *lichuanensis* (S. S. Lai 592, LBG). Bars: A, = 14.29 μm; B, = 50 μm; C, = 38.1 μm; D, = 262.3 μm.

(Zhang & Cai, 1989) and *Y. qianningensis* Y. H. Zhang have long or short, slightly sturdy simple trichomes, and *Y. henryi* (Oliv.) Y. H. Zhang has long simple trichomes (Zhang, 1987a). However, *Hilliella* has only one kind of trichomes, which is shorter and softer with obtuse or rounded apex (Fig. 4: C, D). It is clearly different from all the kinds of trichomes in *Yinshania*.

2.6 Chromosome number

There are clear differences in chromosome number between *Hilliella* and *Yinshania* with seven species of *Hilliella* and four of *Yinshania* having been examined (Tian, 1990; Zhang, 1995c, 1996a; Zhang & Ma, 2001) (Table 2). The *Yinshania* species are all diploids based on x = 6 or 7. Three of the species have 2n = 12 and one, *Y. acutangula*, has 2n = 14. The chromosomal relationships between the x = 6 and x = 7 species remain to be elucidated. The analysis of meiotic metaphase I pairing would probably resolve the chromosomal relationship between these species. ITS sequence data (Koch & Al-Shehbaz, 2000) suggests that 2n = 12 is the ancestral type and the 2n = 14 state is derived.

Table 2 Chromosome numbers of *Hilliella* and *Yinshania*

Species	2n	Altitude (m)	Reference
Yinshania acutangula	14	1500	Tian (1990)
Y. furcatopilosa	12	1300	Zhang (1995c)
Y. henryi	12	1800	Zhang (1995c)
Y. qianningensis	12	1200	Zhang (1996a)
Hilliella fumarioides	42	250	Zhang & Ma (2001)
H. warburgii	42	150	Zhang & Ma (2001)
H. changhuaensis	42	500	Zhang (1996a)
H. paradoxa	42	400	Zhang (1995c)
H. shuangpaiensis	44	1000	Zhang (1995c)
H. sinuata	44	250	Zhang (1996a)
H. yixianensis	42	250	Zhang (1995c)

The *Hilliella* group are mainly hexaploids based on x = 7. Five of the species have 2n = 42 and two, *H. shuangpaiensis* Z. Y. Li and *H. sinuata*, have 2n = 44. ITS data (Koch & Al-Shehbaz, 2000) suggests that the 2n = 44 state has been derived from 2n = 42.. Again the basis for this difference in chromosome number is not known.

Chromosome numbers in *Yinshania* and *Hilliella* support retaining two genera for these plants.

2.7 Geographical distribution

All taxa (except forms) have a fairly well defined geographical distribution, the outcome of evolutionary history and climate. Above the level of species, this distribution is just an attribute of taxa, but cannot be used for their definition. Nevertheless, it can be very helpful when trying to

decide whether a group is monophyletic or not, particularly when the study of distribution is linked to the investigation of cytology and morphological trends (Davis & Heywood, 1963). Both *Hilliella* and *Yinshania* are endemic to China but they have different geographical distributions (Fig. 5 and Table 3). *Hilliella* is only found in subtropical China but *Yinshania* is found predominantly in temperate China. The majority of plants in *Hilliella* (nine out of 11 species and three out of four varieties) are found in Zhejiang and Jiangxi provinces, which implies that this region might be the modern centre of distribution and differentiation of *Hilliella*. In contrast, all the *Yinshania* species, except one, occur in western Sichuan and adjacent areas (including a northern part of the Hengduan mountains and Hubei), which indicates that this region might be the modern centre of distribution and differentiation of *Yinshania*.

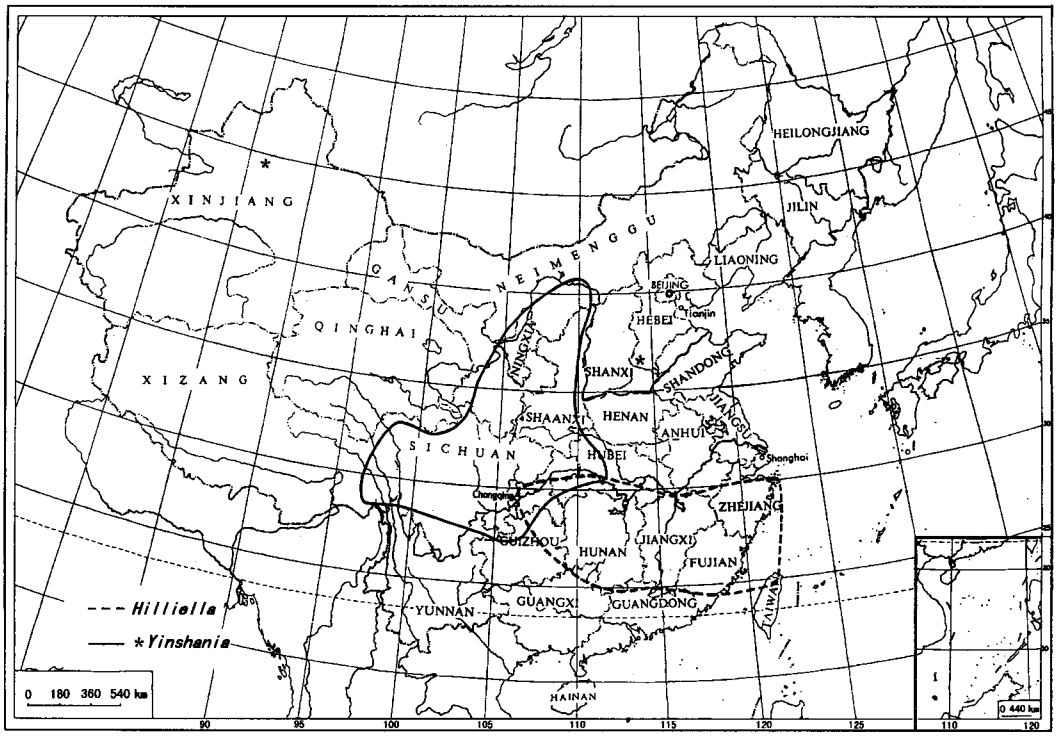


Fig. 5. Distribution of *Hilliella* and *Yinshania*.

Table 3 Distribution of *Hilliella* and *Yinshania*

Region	E China				S China			C China		SW China				NW China			N China		
Province	AH	ZJ	JX	FJ	TW	GD	GX	HN	HB1	SC	GZ	YN	XZ	SX	NX	GS	XJ	NMG	HB2
H	4*	10	7	4	1	3	4	5	1	2	0	0	0	0	0	0	0	0	0
Y	0	0	0	0	0	0	0	0	3	5	1	2	2	1	1	2	1	1	1

H, *Hilliella*; *Y*, *Yinshania*; *, number of species and varieties; AH, Anhui; ZJ, Zhejiang; JX, Jiangxi; FJ, Fujian; TW, Taiwan; GD, Guangdong; GX, Guangxi; HN, Hunan; HB1, Hubei; SC, Sichuan; GZ, Guizhou; YN, Yunnan; XZ, Xizang; SX, Shaanxi; NX, Ningxia; GS, Gansu; XJ, Xinjiang; NMG, Nei Mongol; HB2, Hebei.

The two different distributions provide a geographical reason for these two groups of plants being morphologically and genetically different, and strengthen the argument that they should be separated as two genera.

2.8 Habitat

Most species of *Hilliella* normally grow in shady moist habitats, under trees in forests, on river banks and streamsides, or in moist rocky crevices of cliffs with mosses, at an altitude range of 200 – 1500 m. *Yinshania* species usually grow in dry and sunny habitats on high mountains from 800 to 4500 m, on roadsides, dry bush lands and dry rocky crevices. The conditions in such different ecological habitats have probably encouraged the differentiation of these two groups of plants. In turn, the morphological differentiation may have made them more easily adapted to the environments.

2.9 Other differences

More evidence could be found to support the delimitation of *Hilliella* and *Yinshania* as two genera. For example, the seeds of *Hilliella* species have a shorter dormancy period than those of *Yinshania*. The seeds of *H. fumarioides*, *H. warburgii*, *H. sinuata*, *H. paradoxa* (Hance) Y. H. Zhang & H. W. Li and *H. yixianensis* Y. H. Zhang germinate four or five months after dispersal (Zhang, unpublished data) while the seeds of *Y. acutangula* cannot germinate until they go through two springs and two winters (Tian, 1990).

Little is known of the chemistry of *Hilliella* and *Yinshania*. Only one species, *H. shuangpaiensis*, has been studied (Ina et al., 1993). The results reveal that it contains isothiocyanates which are very similar to the compounds found in *Wasabia japonica* Matsum. and *Cochlearia armoracia* L. Thus *H. shuangpaiensis* has the common name "Chinese wasabi" in Japan. The compounds have a strong pungent flavour and are readily recognized when the plant tissues are crushed, or chewed. Several of the *Hilliella* species, such as *H. changhuaensis*, *H. paradoxa*, *H. sinuata*, *H. yixianensis* Y. H. Zhang and *H. warburgii* also have similar pungent flavours when the leaf and stem are chewed. Such features have not been detected in *Yinshania* species when the leaf and stem were chewed. Al-Shehbaz (1973) believes that "the distribution of the glucosinolates within *Thelypodium* might provide some information of chemotaxonomic value, particularly in connection with certain species complexes". It is known that isothiocyanates are derived from glucosinolates. Therefore, the chemical differences might be another factor to support separation of these two groups of plants. More research will be needed, of course.

In short, *Hilliella* and *Yinshania* are justifiably delimitated as two genera by morphological and biological or ecological evidence (Table 4).

3 Taxonomic treatment

3.1 Hilliella (O. E. Schulz) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 401. 1986; Ying & Zhang in Endemic Gen. Seed Pl. China. 222. 1994. —— *Cochlearia* L. sect. *Hilliella* O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 8: 544. 1923, p. p. excl. *C. serpens* W. W. Smith. et *C. henryi* (Oliv.) O. E. Schulz; et in Engler & Prantl, Nat. Pflanzenfam.

Table 4 Character comparison between *Hilliella* and *Yinshania*

	Hilliella	*Yinshania*
Septum	absent	complete or fenestrate
Seed-size	1 – 2.5 × 0.8 – 1.5 mm	0.5 – 1 × 0.5 – 0.8 mm
Seed-coat	tuberculate	reticulate
Chromosome	2n = 6x = 42 (44) (based on 7 spp.)	2n = 2x = 12 (14) (based on 4 spp.)
Distribution	subtropical China	predominantly temperate China
Habitat	shady moist places	sunny and drier places
Leaf	compound, with 3 or 3 – 5(– 9) leaflets except *H. sinuata*	predominantly pinnatipartite to pinnatisect
Trichomes	simple, short and soft with obtuse or rounded apex	various kinds
Callus mucro	distinct at vein tip, rarely without	absent
Epidermal cell	boundaries between them indistinct in most taxa	boundaries between them distinct in most taxa
Venation	craspedodromous	half-craspedodromous
Chemistry	plants having pungent flavours	plants having no pungent flavours

ed. 2, 17b: 461. 1936, p. p. excl. *C. henryi*, *C. serpens*, *C. hobsonii* H. H. W., *C. himalaica* Hook. f. & Thoms. et *C. minutissima* O. E. Schulz; Kuan in Fl. Reip. Pop. Sin. 33: 100. 1987, p. p. excl. *C. acutangula* O. E. Schulz, *C. microcarpa* K. C. Kuan, *C. furcatopilosa* K. C. Kuan, *C. henryi* et *C. alatipes* Hand.-Mazz. —— *Yinshania* Ma & Y. Z. Zhao sect. *Hilliella* (O. E. Schulz) Y. Z. Zhao in Acta Sci. Nat. Uni. Intramongol. 23: 564. 1992, p. p. excl. ser. *Henryanae* Y. H. Zhang. Type: *Hilliella fumarioides* (Dunn) Y. H. Zhang & H. W. Li.

Cochlearia L. sect. *Sinuata* Kuan in Bull. Bot. Lab. North-East. Forest. Inst. 8: 39. 1980; Kuan in Fl. Reip. Pop. Sin. 33: 98. 1987. Type: *Cochlearia sinuata* Kuan.

Cochleariella Y. H. Zhang & R. Vogt in Acta Bot. Bor.-Occid. Sin. 9: 224. 1989. —— *Cochleariopsis* Y. H. Zhang in Acta Bot. Yunnan. 7: 143. 1985, non Löve & Löve (1976). Type: *Cochleariella zhejiangensis* (Y. H. Zhang) Y. H. Zhang & R. Vogt.

泡果荠属

Annual, biennial or perennial herbs with elongated or rarely tuberous rhizomes, glabrous or sparsely hairy; trichomes simple, short, somewhat soft with obtuse or rounded apex. Stems erect or decumbent. Leaves mostly compound 3 – 5(– 9)-foliolate, rarely simple; leaflet blades ovate, elliptic to oblong-lanceolate, margin having distinct callous mucros at vein tips, rarely not, apex emarginate, obtuse, acuminate to acuminate-caudate with a mucro. Inflorescences complex racemes or corymbose racemes, elongated when fruiting, rarely bracteate; rachis straight or flexuous. Pedicel ascending or recurved, or distinctly reflexed. Sepals oblong or boat-shaped, spreading or slightly erect. Petals white or pinkish, spreading or slightly spreading, obovate or spatulate, base cuneate

or becoming a short claw 1 – 2 mm long, apex rounded. Filaments white; anthers white or yellow, elliptic-cordate or oblong, rarely globose. Lateral nectar glands in pairs, ovate-triangular; middle ones absent. Ovary globose, ovoid or oblong-ellipsoid with ovules (1 –)2 – 17(– 21). Silicule dehiscent, oblong, ellipsoid, subglobose, obovoid, or suborbicular, valves convex or slightly convex, or flattened, smooth or pustulate, rarely with club-like trichomes; false septum completely absent. Style distinct; stigma entire, depressedly capitate. Seeds ovate, slightly flattened, 1 – 2.5 × 0.8 – 1.5 mm, tuberculate; cotyledons incumbent, rarely accumbent.

When a plant was described as a new species, *Cochlearia fumarioides* by Dunn (1908), he stated that "This interesting little species differs widely from most Cochlearias in its habit and from all Cochlearias in its blistered fruit, but the divergence does not show sufficient foundation for a new genus." This interesting discovery did not get any attention until 1923 when Schulz studied Crucifers and assigned all *Cochlearia* species found in the SE China and one from Sikin (Sri Lanka) to a new section, *Cochlearia* L. sect. *Hilliella* O. E. Schulz. Erection of the new section was apparently a response to Dunn's interesting discovery in 1908. But he did not designate a type for his new section. Since then, Handel-Mazzetti (1931) and Kuan (Kuan & An, 1980) have accepted this section. In 1986 I proposed the elevation of sect. *Hilliella* to the rank of genus because this group of plants has very little in common with *Cochlearia* not only at the sectional but also the generic rank based on my research. In the meantime, *H. fumarioides* (Dunn) Y. H. Zhang & H. W. Li (as *Cochlearia fumarioides* Dunn) was selected as the type for the genus *Hilliella*. Kuan (Kuan & An, 1980) established another section, *Cochlearia* L. sect. *Sinuata* Kuan based on the single species, *C. sinuata* Kuan. However, I found section *Sinuata* is almost identical to *Hilliella* and subsequently reduced it to synonymy within *Hilliella*.

Cochleariella Zhang & Cai was established as a monotypic genus in 1989 containing only one species, *C. zhejiangensis* (Y. H. Zhang) Y. H. Zhang & R. Vogt (Zhang & Cai, 1989). However, *C. zhejiangensis* is actually conspecific with *Cochlearia fumarioides* (= *H. fumarioides*), as Al-Shehbaz et al. (1998) pointed out. *Cochleariella* is thus reduced to synonymy of *Hilliella* in this paper.

After revision of this group of plants, 11 species and four varieties belong to *Hilliella*.

Key to the taxa of *Hilliella*

1. Fruit smaller, 1.5 – 2.5(– 3) × 1.5 – 2(– 3) mm, subspheroidal to ovate-ellipsoid; basal leaves 5 – 10, simple, suborbicular or broadly elliptic; leaflets of middle and lower stem leaves usually < 1 cm wide, 2 – 3-lobed; uppermost leaves usually simple, mostly deeply 3-lobed.
   2. Valves densely covered with membranous pustules or club-like trichomes; fruiting pedicels (3 –)5 – 11 mm long; 2 – 8 fruits per cm of rachis ..... 3.1.1 **H. fumarioides**
   2. Valves glabrous; fruiting pedicels 4 – 5 mm long; 8 – 12(– 16) fruits per cm of rachis ..... 3.1.2 **H. warburgii**
1. Fruit larger, 2.5 – 6(– 12) × (1.5 –)2 – 3(– 5) mm, ovoid, obovoid, ellipsoid to oblong, or broadly elliptic to suborbicular, (3 –)4 – 6 × 3 – 4(– 5) mm; basal leaves often withered early; leaflets of the middle and lower

stem leaves > 1 cm wide; uppermost leaves simple, never deeply 3-lobed.

3. Most or all leaves simple, entire, repand, or sinuate, rarely lowermost few trifoliolate ··· 3.1.3 **H. sinuata**

4. Lowermost leaves simple; seeds 0.8 – 0.9 mm long ····· 3.1.3a var. **sinuata**

4. Lowermost leaves trifoliolate; seeds 1.2 – 1.3 mm long ····· 3.1.3b var. **qianwuensis**

3. Leaves compound, with 3 – 7(– 9) leaflets.

5. Fruit oblong; seeds 7 – 10.

6. Leaf papery; fruiting pedicels obviously reflexed in fruit; ovules 12 – 18 ····· 3.1.4 **H. rivulorum**

6. Leaf membranous; fruiting pedicels widely spreading in fruit; ovules 8 – 10 ····· 3.1.5 **H. hui**

5. Fruit ovoid, obovoid to ellipsoid or suborbicular, rarely oblong; seeds 1 – 3.

7. Fruit conspicuously flattened parallel to replum.

8. Plants < 30 cm tall, with elongated rhizome to 5 mm in diam.; stems several, ascending or diffusive; leaflets of middle and lower stem leaves usually < 1 cm wide ····· 3.1.6 **H. hunanensis**

8. Plants (30 –) 50 – 100 cm or over tall, with a thick tuberous rhizome 2 – 4 cm wide; 1 or few stems from rhizome, usually erect; leaflets of middle and lower leaves > 1 cm wide.

9. Petals ca. 3 mm long; fruit narrowly obovate ····· 3.1.7 **H. rupicola**

9. Petals 1.5 – 2 mm long; fruit orbicular ····· 3.1.8 **H. shuangpaiensis**

7. Fruit not compressed, with convex valves.

10. Leaflet apex long acuminate or caudate, with trichomes on abaxial leaf and on veins of adaxial leaf ····· 3.1.9 **H. changhuaensis**

11. Infructescence shorter, becoming densely paniculate; terminal leaflet usually slightly lobed ····· 3.1.9a var. **changhuaensis**

11. Infructescence longer and lax; terminal leaflet not lobed.

12. Style ca. 2 mm long in fruit ····· 3.1.9b var. **longistyla**

12. Style 0.5 – 1.5 mm long in fruit.

13. Plant larger with stem to 1 m tall or over; silicules oblong or obovate-ellipsoid ca. 5 mm long ····· 3.1.9c var. **lichuanensis**

13. Plant shorter with stem ca. 0.5 m tall; silicules obovoid ca. 3 mm long ····· 3.1.9d var. **guangdongensis**

10. Leaflet apex obtuse to acute or subacuminate, glabrous or rarely with sparse trichomes on leaf.

14. Infructescence rachis conspicuously flexuose; fruiting pedicels slender, 5 – 6 mm long; fruit subglobose-obovoid ····· 3.1.10 **H. yixianensis**

14. Infructescence rachis straight, very rarely irregularly twisted apically; fruiting pedicels shorter, (1.5 –)2 – 4 mm long; fruit unequally obovoid to ellipsoid ····· 3.1.11 **H. paradoxa**

3.1.1 Hilliella fumarioides (Dunn) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 403. 1986, p. p. quoad Pl. Fujian. —— *Cochlearia fumarioides* Dunn in J. Linn. Soc. Bot. 38: 355. 1908. —— *Yinshania fumarioides* (Dunn) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 568. 1992, p. p. quoad Pl. Fujian.; Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 85. 1998, syn. nov., p. p. excl. syn. *C. warburgii* O. E. Schulz et *H. warburgii* (O. E. Schulz) Y. H. Zhang & H. W. Li var. *albiflora* S. X. Qian. Type: China. Fujian (福建): Nanping (南平), Buong Kang, 1905-05-04 (fr.), S. T. Dunn 2360 (holotype, HK (photo!); isotype, GH (photo!), K!).

Cochleariella zhejiangensis (Y. H. Zhang) Y. H. Zhang & R. Vogt ex Zhang & Cai in Acta Bot. Bor.-Occid. Sin. 9: 224. 1989 (as *Cochleariopsis zhejiangensis* Y. H. Zhang in Acta Bot. Yunnan. 7: 144. 1985). —— *Yinshania zhejiangensis* (Y. H. Zhang) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 569. 1992. Type: China. Zhejiang (浙江): Suichang (遂昌), Jiulongshan (九龙山), 720 m, 1983-05-17 (fl., fr.), C. Ling 3154 (holotype, ZJMA!; isotype, HZU!).

棒毛泡果荠(新拟)

Annuals or biennials, 6 – 36 cm tall, glabrous throughout except for fruit valves. Stems branched lower to above. Basal leaves with suborbicular or broadly ovate blades 1 – 1.5 × 1 – 1.5 cm, usually shallowly 3 – 5(– 7)-lobed or crenate; petiole 1.5 – 3(– 5) cm long. Middle and lower stem leaves 3-foliolate; terminal leaflet blade ovate-orbicular or oblong-obovate, (0.5 –)1 – 2 × 0.3 – 1 cm, base cuneate to subcordate, margin 3-lobed, apex truncate to slightly emarginate; lateral leaflet blade obliquely ovate, 0.4 – 1.5 × 1(– 1.5) cm, margin irregularly lobed to crenate, apex truncate to slightly emarginate; leaflet blade without distinct callose mucro at vein tip; petiolule 1 – 5(– 8) mm long; petiole 2 – 3.5 cm long. Upper leaves similar to middle and lower leaves, gradually reduced upward. Uppermost leaves usually simple, deeply 3-lobed, with lobes oblong or ovate-orbicular; petiole absent or up to 1 mm long. Racemes terminal and lateral, (6 –)12 – 36-flowered, ebracteate, with 2 – 8 fruits per cm on rachis in fruit. Pedicel slender, usually horizontal in fruit, 5 – 11 mm long. Sepals oblong, 1.3 – 1.4(– 1.5) × 0.5 – 0.8 mm. Petals white or purplish, elliptic or spatulate, (1.5 –)2.3 – 2.6 × 0.8 – 1.3 mm, base short-clawed. Ovary subspheroid to ellipsoid with style (0.3 –)0.4 – 0.5(– 0.9) mm. Fruit sphaeroid, ovoid to ovate-ellipsoid, 1.8 – 2.5(– 3) × 1.5 – 2(– 3) mm, densely with membranous pustules or club-shaped trichomes. Style 0.5 – 0.8 mm. Seeds (1 –)2, ovoid or ovate-ellipsoid, (1.2 –)1.5 – 2(– 2.2) × 1 – 1.2 mm. 2n = 42. Fl. and fr. May – Aug.

Additional specimens examined. **China. Zhejiang** (浙江): Longquan (龙泉), Z. F. Zhang et al. 233 (HHBG, HZU), Anonymous 1882 (HHBG), S. Y. Zhang et al. 2823 (HHBG); Pan'an (磐安), L. Hong 4034 (ZJMA); Suichang (遂昌), M. B. Deng et al. 82109 (NAS); Tonglu (桐庐), Y. H. Zhang 97001 (ZJMA); Songyang (松阳), Y. H. Lou et al. SY296 (ZJFC).

Distribution and habitat: Fujian and Zhejiang. On wet shady slopes, wet vertical rocks, or along streams; 280 – 950 m.

Since *Cochlearia fumarioides* was published (Dunn, 1908) it has been misunderstood for a long time. For example, the name was used for another plant, *H. hunanensis* by Zhang (1986, 1990), Kuan (1987), Zhao (1992), Lu (1993) and Ying & Zhang (1994) because its type specimen was not available. After the type of *C. fumarioides* was examined, it was clear that they are different species. The fruits of *C. fumarioides* are much smaller and have clearly dense pustules or club-like trichomes. In contrast, the fruits of *H. hunanensis* are bigger and have very tiny pustules or not.

In Flora Reipublicae Popularis Sinicae 3: 106, *Cochlearia fumarioides* described by Kuan (1987) included two species, *C. fumarioides* and *H. hunanensis*, based on the specimens (kept in PE) identified by Kuan in 1976. He correctly identified the specimens "Zhang et al. 2823" as *Cochlearia fumarioides*, but the specimen of Guangfu Forest Investigation Team 187 (PE) was misidentified as *Cochlearia fumarioides* which should be *H. hunanensis*.

For the same reason as above, in 1985, a specimen which slightly differed from *Cochlearia fumarioides* was described as a new species, *Cochleariopsis zhejiangensis* Y. H. Zhang, and the monotypic genus, *Cochleariopsis* Y. H. Zhang (= *Cochleariella* Y. H. Zhang & R. Vogt) (Zhang, 1985) was proposed. More careful comparison of the type of *Cochlearia fumarioides* with all collections of *Cochleariopsis zhejiangensis* in recent work reveals that *Cochleariopsis zhejiangensis* is conspecific with *Cochlearia fumarioides* and should be reduced to a synonym of *Cochlearia fumarioides*, as Al-Shehbaz et al. pointed out (1998).

3.1.2 Hilliella warburgii (O. E. Schulz) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 405. 1986. —— *Cochlearia warburgii* O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 8: 545. 1923. —— *Cochleariopsis warburgii* (O. E. Schulz) L. L. Lu in Acta Phytotax. Sin. 31: 287. 1993. —— *Yinshania warburgii* (O. E. Schulz) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 568. 1992, syn. nov. Type: China. Zhejiang (浙江): Ningbo (宁波), 1887-05-24 (fl., juv. fr.), Warburg 6340 (holotype, B!).

Hilliella warburgii (O. E. Schulz) Y. H. Zhang & H. W. Li var. *albiflora* S. X. Qian in Bull. Res. Harbin 10 (4): 63. 1990, syn. nov. Type: China. Zhejiang (浙江): Tiantai (天台), Tiantaishan(天台山), Huading (华顶), 950 m, 1987-05-24 (juv. fr.), S. X. Qian 10002 (holotype, Medical Research Institute, Shanghai Railway Medical College!).

浙江泡果荠

Annuals or biennials, 12 – 36 cm tall, glabrous. Stems erect, branched lower to above. Basal leaves simple, orbicular, suborbicular or broadly ovate, 1.2 – 2.2 × 1.5 – 2.2 cm, 5(– 7)-lobed or crenate; petiole 3 – 4.5 cm long. Middle and lower stem leaves 3-foliolate; terminal leaflet blade ovate or elliptic, 1 – 1.8 × 0.5 – 0.9 cm, base cuneate to subcordate, margin 3-lobed, apex truncate or slightly emarginate; lateral leaflet blade obliquely ovate, usually 2-lobed; leaflet without distinct callosities; petiolule 1 – 2(– 3) mm long; petiole 0.5 – 2.5 cm long. Upper leaves similar to middle and lower ones, gradually reduced upward. Uppermost leaves usually simple, deeply 3-lobed. Racemes terminal and lateral, 12 – 30-flowered, ebracteate, with (8 –) 12 – 16 fruits per cm on rachis in fruit. Pedicel slender, horizontal, 4 – 5 mm long in fruit. Sepals oblong, 1.4 – 1.6 × 0.5 – 0.8 mm. Petals white or purplish, elliptic, (1.5 –)2 – 2.5 × 1.2 – 1.4 mm, with base short claw. Ovary ellipsoid. Fruit subspheroid or ovate-ellipsoid, 1.4 – 2 × 1.2 – 1.8 mm, plump, glabrous, with nerves under lens. Seeds (1 –)2, ovoid, 1 – 1.5 × 0.8 – 1.2 mm. 2n = 42. Fl. Apr. – Jun. and fr. May – Aug.

Additional specimens examined. **China. Zhejiang** (浙江): Jiande (建德), L. Hong 1076 (HHBG); Leqing (乐清), Anonymous 2376 (HHBG); Lin'an (临安), B. Y. Ding 1511

(HZU); Linhai (临海), Z. Z. Zheng & Z. F. Zhang 6808 (HZU); Putuo (普陀), R. H. Zhang & Y. L. Xu 1333 (ZJFC), Anonymous 6137 (PE, SHM); near Suichang (遂昌), R. C. Ching 1674 (US); Tiantai (天台), X. Y. He 0247 (HHBG), L. Hong 97001 (ZJMA), Z. F. Zhang et al. 7147 (HZU); Xianju (仙居), Anonymous 7873 (HHBG); Ningbo (宁波), Z. Z. Zheng 5572 (HZU), Anonymous 4271 (PE); Zhuji (诸暨), M. B. Ding et al. 3751 (ZJFC), Y. H. Zhang 99001 (ZJMA), Y. H. Zhang 99002 (ZJMA).

Distribution and habitat: Zhejiang. In wet shady slopes, rocky cliffs, forests, or along streams; 150 – 800 m.

Al-Shehbaz et al. (1998) combined *H. fumarioides*, *Cochlearia warburgii* (= *H. warburgii*), *Cochleariella zhejiangensis* into one species. I agree to unit *Cochleriella zhejiangensis* with *H. fumarioides*, but it is not reasonable to treat *H. warburgii* and *H. fumarioides* as one species. In fact, they are two easily separated species by their fruits and other characters. *H. warburgii* has glabrous fruits (Fig. 6: E, F) with shorter pedicels up to 5(– 6) mm long (Fig. 6: D) whereas *H. fumarioides* has fruits covered by dense membranous pustules or club-like trichomes up to 1 mm long (Fig. 6: B, C) with longer pedicels up to 11 mm long (Fig. 6: A). In addition, *H. warburgii* has a shorter infructescence (2 – 4.5 cm long) with (8 –)12 – 16 fruits per cm of rachis (Fig. 6: D) whereas *H. fumarioides* has much longer infructescence (up to 13 cm long) with 2 – 8 fruits per cm of rachis (Fig. 6: A). Furthermore, Wei & Zhou (1998) reported that *H. fumarioides* is amphistomatic, with stomata on both surfaces of its leaves but *H. warburgii* has stomata only on the abaxial face of the leaves. My examination of the stomata of both species with SEM (Zhang, unpublished data) confirmed the report by Wei & Zhou. Geographical distributions of these two species are different too. *H. warburgii* is found in eastern and southeastern Zhejiang, whereas

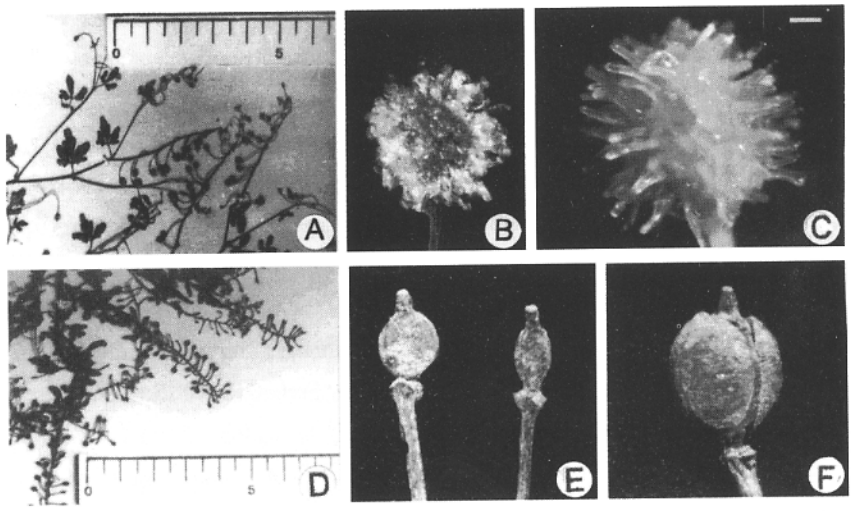


Fig. 6. Infructescences and fruits of *Hilliella fumarioides* and *H. warburgii*. **A – C**, *H. fumarioides*. **A**, Infructescences (C. Ling 3154, ZDC) showing fruits loosely arranged. **B**, Dry juvenile fruit (Z. F. Zhang et al. 233, HHBG) showing surface with club-like trichomes. **C**, Mature fruit (Z. F. Zhang et al. 233, HHBG) showing surface with club-like trichomes. **D – F**, *H. warburgii*. **D**, Infructescences (Z. F. Zhang et al. 7147, HZU) showing fruits densely arranged. **E**, Juvenile fruits (Z. F. Zhang et al. 7147, HZU) showing smooth surface. **F**, Mature fruit (Z. F. Zhang et al. 7147, HZU) showing smooth surface. Bars: **B**, **C**, **E**, **F**, = 0.5 mm.

H. fumarioides mainly in middle and southern Zhejiang and northeastern Fujian. The above morphological features were investigated in the field many times, and were found to be very steady, and not affected by the individual maturity of the plant, in particular, the pustule trichomes (Lu, 1993). Therefore, *H. warburgii* and *H. fumarioides* are justified as separate species by all above evidence.

Both *H. warburgii* and *H. fumarioides* have very small fruits and half-lobed or deeply lobed leaflets that make them different from the rest of the species in *Hilliella*. They have been treated differently by different taxonomists. For example, Lu (1993) recognized *Cochleariella* (as *Cochleariopsis*, non Löve & Löve, 1976) as an independent genus and transferred *Cochlearia warburgii* from *Cochlearia* to *Cochleariella*, combining it with *Cochleariella zhejiangensis* as one species, *Cochleariella warburgii*. Combination of *C. warburgii* and *C. zhejiangensis* into one species is not accepted here. The reason was stated as above. However, Lu's treatment at least shows that Lu also recognized that these two species are not only morphologically similar but also different from the rest of the species of *Hilliella*.

Although *H. fumarioides* and *H. warburgii* are somewhat special and different from the remaining species in *Hilliella*, they nevertheless are similar in several important characters, such as fruit without septum, tuberculate seed coats and 2n = 42 in chromosome count (Zhang & Ma, 2001). Therefore, the present author does not advocate separation of *H. fumarioides* and *H. warburgii* from *Hilliella*.

3.1.3 Hilliella sinuata (Kuan) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 404. 1986. —— *Cochlearia sinuata* Kuan in Bull. Bot. Lab. North-East Forest Inst. 8: 39. 1980. —— *Yinshania sinuata* (Kuan) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 88. 1998, syn. nov. Type: China. Jiangxi (江西): Suichuan (遂川), 1970-05-31 (fl.), L. K. Dai 159 (holotype, PE!; isotype, PE!).

弯缺泡果荠

Annuals or biennials, 10 – 20 cm tall. Stems erect or subdecumbent, branched. Leaf blade simple or lowermost trifoliolate, ovate to ovate-elliptic, (1.5 –)2 – 6 × 1 – 4 cm, base cordate to subtruncate, margin sinuate to repand, with distinct apiculate callous mucros at vein tips, apex obtuse with mucro; petiole (0.5 –)1 – 3.5(– 6) cm. Racemes lax, usually being two with an opposite leaf at the top of stem or branch. Sepals oblong-ovate, ca. 2 mm long; petals white, obovate, ca. 2.5 mm long. Fruiting pedicel spread in flower, distinctly reflexed in fruit, 5 – 8(– 12) mm long. Fruit oblong, 5 – 13 × (1 –)1.5 – 3 mm, glabrous. Style 0.8 – 1.5 mm long. Seeds 7 – 14 (– 21), 0.8(– 1.2) – 0.9(– 1.3) mm long.

3.1.3a var. **sinuata**

Yinshania sinuata ssp. *sinuata* (Kuan) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 89. 1998, syn. nov.

Leaf blade simple or sometimes with one (or two) very small lateral lobule(s) on petiole. Fruit 5 – 8 × (1 –)1.5 – 1.8 mm. Seeds 7 – 14, 0.8 – 0.9 mm long. 2n = 44. Fl. Mar. – Apr. Fr.

May.

Additional specimens examined. **China. Guangdong** (广东): Renhua (仁化), W. T. Tsang 26144 (A, NAS). **Hunan** (湖南): Xinning (新宁), Luo 2094 (PE). **Jiangxi** (江西): Ji'an (吉安), L. K. Dai 240 (PE); Taihe (泰和), S. S. Lai 467 (LBG); Wuyuan (婺源), Q. H. Li & C. Chen 73 (LBG), 345 (PE), M. B. Deng 87176 (NAS). **Zhejiang** (浙江): Kaihua (开化), L. Hong 966 (HHBG).

Distribution and habitat: Guangdong, Hunan, Jiangxi, Anhui, and Zhejiang. On streamsides, rocky crevices and in dense forest from near sea level to 700 m.

3.1.3b var. **qianwuensis** Y. H. Zhang in Acta Bot. Yunnan. 8: 405. 1986. —— *Yinshania sinuata* (Kuan) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo ssp. *qianwuensis* (Y. H. Zhang) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 89. 1998, syn. nov. Type: China. Jiangxi (江西): Qianwu (寻邬), Q. M. Hu & Q. H. Li 1761 (holotype, LBG!; isotype, PE!).

寻邬弯缺泡果荠

Upper stem leaves simple, whereas lower or lowermost leaves trifoliolate; fruit 6 – 13 × 3 mm; seeds 15 – 21, 1.2 – 1.3 mm long. Fr. in May.

Additional specimen examined. China. Jiangxi (江西): Xunwu (寻邬), Q. M. Hu 1701 (KUN).

Distribution and habitat: Jiangxi. Forests or along streamsides; ca. 200 m.

H. sinuata is the only taxon having simple leaves in the genus. Zhao (1992) suggested that *H. sinuata* should be placed in *Cochlearia*. However, the leaves of *Cochlearia* are somewhat fleshy whereas *H. sinuata* has membranous or papery leaves. The petioles of var. *sinuata* sometimes have 1 – 2 very small lobules and in another variety, var. *qianwuensis*, the stem leaves, at least the lowermost, are compound with leaflets. *H. sinuata* has distinct apiculate callous mucros at vein tips and has no septa in the fruits. So, *H. sinuata* should be maintained in *Hilliella*. Evidence from cytology (chromosome number of 2n = 44) and molecular data (Koch & Al-Shehbaz, 2000) also confirm that *H. sinuata* belongs to *Hilliella*.

The holotype of var. *qianwuensis* is the specimen of Q. M. Hu 1761 kept in LBG and the isotype kept in PE. The other collection (Q. M. Hu 1701) was deposited in KUN but is not a type specimen and has never been annotated as any kind of type (Al-Shehbaz et al., 1998).

3.1.4 Hilliella rivulorum (Dunn) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 404. 1986. —— *Nasturtium rivulorum* Dunn in J. Linn. Soc. Bot. 38: 354. 1908. —— *Cochlearia rivulorum* (Dunn) O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 8: 546. 1923. —— *Yinshania rivulorum* (Dunn) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 87: 1998, syn. nov. Type: China. Fujian (福建): Fong Kong Tze, near Fuzhou (福州), along the mossy banks of rivulets in shady woods, 1905-05 (juv. fr.), Dunn 2354 (holotype, HK (photo!); isotype, GH (photo!), K!).

Cochlearia formosana Hayata in J. Coll. Sci. Imp. Univ. Tokyo 30 (1): 32. 1911. ——

Hilliella formosana (Hayata) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 403. 1986. —— *Yinshania formosana* (Hayata) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 567. 1992. Type: China. Taiwan (台湾): Taibei (台北), Shenkeng (深坑), 1906-06-08 (fr.), T. Kawakami 1390 (holotype, TI!).

Hilliella alatipes (Hand.-Mazz.) Y. H. Zhang & H. W. Li var. *micrantha* Y. H. Zhang in Acta Bot. Yunnan. 8: 403. 1986, syn. nov. Type: China. Hunan (湖南): Jianghua (江华), 1973-04-22(fl., juv. fr.), Hunan Institute of Chinese Medicine 7300069 (holotype, IBSC!).

河岸泡果荠

Annuals or biennials, glabrous throughout. Basal leaves simple, suborbicular to ovate, 1.4 – 4× 1.4 – 2 cm; petiole 2 – 6 cm long. Stem leaves 3-foliolate, leaflet blade ovate to oblong, (1 –)2 – 5 × (0.8 –)1 – 3 cm, base cordate to rounded or cuneate, margin repand or rarely sinuate-toothed, with conspicuous callous mucros terminating veins, apex obtuse or shortly acute with a mucro; terminal leaflet larger than laterals; petiolule (0.2 –)0.5 – 2.2(– 1.2) cm long; petiole 1.5 – 3 cm long. Upper leaves similar to lower ones, whereas uppermost simple at inflorescence base. Racemes lax, terminal or lateral, rachis straight. Pedicel reflexed in fruit. Sepals 1.5 – 2 mm long. Petals pink, obovate, 1.8 – 2.5 mm long, minutely clawed. Ovary ellipsoid, with 12 – 18 ovules. Fruit oblong 4 – 6 × 1.2 – 1.5 mm. Seeds 7 – 10. Fl. Apr. Fr. May – Dec.

Additional specimens examined. **China. Anhui** (安徽): Yi Xian (黟县), 1985-05-20 (fl., fr.), S. X. Qian 19003 (HSNU). **Fujian** (福建): Tainin (泰宁), Z. S. Chen 135 (FNU). **Guangxi** (广西): Yaoshan (瑶山), Anonymous 471 (NAS). **Taiwan** (台湾): Ilan (宜兰), S. Sasaki s. n. (TI); Taipei (台北), Anonymous 534 (TI), M. T. Kao 7166 (TI), M. Togashi s. n. (TI), Suzuki ST-19075 (PE), S. Sasaki s. n. (TNS). **Zhejiang** (浙江): Changhua (昌化), X. Y. He 21828 (HHBG).

Distribution and habitat: Anhui, Fujian, Guangxi, Hunan, Taiwan, and Zhejiang. On shady river banks, mountain slopes; 300 – 800 m.

The plants from Taiwan are bigger and grow more luxuriantly than those in China mainland. It seems that the environments in Taiwan are more suitable for their growth.

Al-Shehbaz et al. (1998) referred the type specimen of *Cochlearia formosana* to a collection from Taiwan Herbarium numbered as 1390, collected by Hayata on Feb. 27, 1908. But this is not the type annotated by Hayata (1911). The type of *C. formosana* designated by Hayata (1911) is the specimen kept in TI also numbered 1390, but collected by Kawakami on Jun. 8, 1906.

H. sinuata and *H. rivulorum* are more closely related to each other than to the species in the genus. Both of them have narrow ellipsoid fruits with eight or more seeds and reflexed pedicels. They both grow in shady habitats, such as forest, river bank and streamsides. All these make them easily separated from the rest of the species of *Hilliella*.

3.1.5 Hilliella hui (O. E. Schulz) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 404. 1986. —— *Cochlearia hui* O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 8: 546. 1923. —— *Yinshania hui* (O. E. Schulz) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol.

23: 567. 1992; Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 93. 1998, syn. nov. Type: China. Jiangxi (江西): Anfu (安福), Wookungshan, 1500 m, 1921-04 (fl., juv. fr.), H. H. Hu 731, 752 (syntypes, B-destroyed in World War II).

武功山泡果荠

Annual slender herb, glabrous throughout, (4 -)7 - 15(- 20) cm tall. Stems branched, flexuous. Basal leaves trifoliolate or sometimes having only one lateral leaflet; terminal leaflet ovate to subcordate, 0.4 - 0.8 × 0.5 - 1 cm, base unequally cuneate or slightly cordate, margin coarsely crenate with distinct mucros at tooth apices, apex emarginate and mucronulate; lateral leaflets smaller and with shorter petiolules, obliquely ovate; petiolule 3 - 5 mm long; petiole 1 - 3 cm long. Middle stem leaves trifoliolate, with ovate or subelliptic terminal leaflet (0.8 -)1 - 2.5 × 0.7 - 2 cm and much smaller lateral leaflets 0.5 - 1.5 × 0.5 - 1.3 cm; petiolule 2 - 4 mm long; petiole 1 - 2 cm long. Uppermost leaves usually simple, with shorter petiole 1 - 3 mm long. Racemes lax in flower, 8 - 10-flowered, sometimes with ca. 3 flowers remote and an uppermost bract-like leaf at lowermost place of inflorescence. Lowermost pedicels 0.8 - 1(- 1.5) cm long in fruit. Sepals oblong-ovate, 1.8 - 2 mm long. Petals white to pinkish, 2.8 - 3 mm long, ovate, base cuneately becoming short claw, apex rounded. Stamens 2 - 2.5 mm long; anthers oblong, ca. 0.5 mm long. Ovary 8 - 10 ovuled. Style ca. 0.7 mm long; stigma depressed. Fruit ellipsoid, (3 -)4 - 6 × (1 -)1.2 - 2 mm; valves minutely pustulate. Fl. Apr. Fr. May.

Additional specimens examined. **China. Zhejiang** (浙江): Taishun (泰顺), G. Y. Li et al. TH004, 0656 (ZM).

Distribution and habitat: Jiangxi and Zhejiang. Forest, shady river bank or streamsides.

The type of *H. hui* is not available. Having visited Berlin Herbarium, I have concluded that the type specimen was most likely destroyed in World War II as known from Professor Hu (Hu Xiu-Ying, pers. comm. 1985). Dr. R. Vogt was unable to find the type of *C. hui* in K or E (Vogt, pers. comm. 1990). In 1992, several specimens collected in Taishun of Zhejiang Province by Li et al. almost fully conform to Schulz's (1923) original description of *H. hui*.

Hilliella hui and *H. hunanensis* Y. H. Zhang are very similar in shape of leaf (Fig. 3: C, D), hence the combination of *H. hui* and *H. hunanensis* was made by Zhao (1992). However, they differ in shapes and sizes of fruits. *H. hui* has ellipsoid fruits, (3 -)4 - 6 × (1 -)1.2 - 2 mm with plump valves and 6 - 8 seeds whereas *H. hunanensis* has broadly elliptic to suborbicular fruits, (2.5 -)3 - 6 × (2.5 -)3 - 5 mm with flat valves and 2 - 3 seeds. Besides, the former is a slender annual plant without a rhizome whereas the latter is a perennial plant with an elongated rhizome up to 5 mm in diam. Therefore, they are not closely related to each other. However, Al-Shehbaz et al. (1998) believed that "*H. hui* is mostly closely related to *H. hunanensis*" "on the basis of their inflorescences" and described that *H. hui* "bracteate to apex". In fact, in *Hilliella* only *H. hunanensis* and *H. rupicola* (Zhang & Shao) Y. H. Zhang (Zhang & Xu, 1990) have bracteoles on the inflorescences. *H. hunanensis* has bracteoles to the apex or along the lower half of the inflorescences, whereas *H. rupicola* has bracteoles on the lowermost 1 - 3 flowers. *H. hui* is

absent of bracteoles. The description of the inflorescences of *H. hui* by Al-Shehbaz et al. (1998) does not conform with Schulz's original description and my observations of *H. hui*.

3.1.6 Hilliella hunanensis Y. H. Zhang in Acta Bot. Yunnan. 9: 160. 1987. —— *Yinshania hunanensis* (Y. H. Zhang) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard. Pap. Bot. 3: 92. 1998, syn. nov. Type: China. Hunan (湖南): Hengshan (衡山), Guangjisi (广济寺), 750 m. 1963-05-17 (fl.), L. H. Liu 15702 (holotype, PE!; isotype, KUN!)

Cochlearia fumarioides auct. non Dunn: Kuan in Fl. Reip. Pop. Sin. 33: 106, pl. 23, fig. 7. 1987, p. p. excl. Pl. Fujian. et Zhejiang. —— *Hilliella fumarioides* auct. non (Dunn) Y. H. Zhang & H. W. Li: Zhang in Acta Bot. Yunnan. 8: 403. 1986, p. p. excl. Pl. Fujian., et Hong Kong. —— *Yinshania fumarioides* auct. non (Dunn) Y. Z. Zhao: Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 568. 1992, p. p. excl. Pl. Fujian., et Hong Kong.

湖南泡果荠

Perennials with rhizomes thick to 5 mm in diam., glabrous throughout or rarely with sparsely adpressed hairs on adaxial surface of leaf. Stems slender, branched from base, ascending. Basal and lowermost stem leaves 3 – 5-foliolate; leaflet blade broadly ovate to suborbicular, (0.5 –)1 – 2.5 × (0.3 –)1 – 1.5 cm; terminal leaflet cuneate at base; lateral leaflets smaller than terminals, oblique at base, margin shallowly 3 – 5(– 7)-lobed to repand, apex obtuse or slightly emarginate; margin and apex with veins ending in a distinct mucro; petiolule 0.1 – 0.4(– 1.2) cm; petiole (2 –)5 – 8.5 cm. Middle and upper stem leaves gradually reduced in size, 3-foliolate, margin shallowly 3 – 5-lobed; petiole 1 – 2(– 2.5) cm long. Margin and apex of leaflet blades with conspicuous callous mucros terminating veins. Inflorescences corymbose raceme, lax, considerably elongated in fruit, bracteolate to apex or along lower half; bracteoles simple, considerably reduced in size upward. Fruiting pedicel slender, usually recurved, 0.8 – 2 cm long. Sepals (0.5 –)1 – 1.6 mm long. Petals white, (0.75 –)1.5 – 2.5 × 1.2 – 1.5 mm. Fruit orbicular to broadly elliptic, (3 –)4 – 5(– 6) × (2.5 –)3 – 4 (– 5) mm, flattened; valves diminutely pustulate in juvenescent phase and inconspicuous in fruit. Seeds 2 – 3(– 4). Fl. May – Jun. Fr. Jun. – Aug.

Additional specimens examined. **China. Guangxi** (广西): Longsheng (龙胜), Guangfu Forest Investigation Team 187 (IBSC, MO, PE). **Hunan** (湖南): Hengshan (衡山), S. Cheng 3466 (IBSC, MO); Yizhang (宜章), S. F. Wu 7233 (SHCT), M. X. Huang 112168 (FJSI, MO); Ling Xian (酃县), Y. L. Li et al. 646 (HUTM). **Jiangxi** (江西): Lushan (庐山), K. C. Kuan 74571 (PE), X. Q. Wang 87010 (NAS), C. Y. Wu et al. L-140 (KUN), Y. G. Xiong 5613 (LBG), Z. Z. Zheng s. n. (HZU); Xingzi (星子), Huang et al. 121 (PE). **Zhejiang** (浙江): Yongjia (永嘉), C. S. Ding & G. Y. Li 1704 (ZJFC).

Distribution and habitat: Guangxi, Hunan, Jiangxi and Zhejiang. Growing in wet shady habitats, forests, valleys, mountain rocky grottos, along streamsides.

The type specimen (L. H. Liu 15702) collected from Hengshan, Hunan has leaves, flowers and fruits larger than those collected from Zhejiang, Jiangxi and Guangxi. The basal leaves usually have 5 leaflets 5 – 7-lobed and bracteoles only along the lower half of the inflorescence. The

specimens from Zhejiang, Jiangxi and Guangxi have basal leaves usually with 3 leaflets shallowly 5-lobed and bracteoles from the base to the apex of the inflorescence. These differences may be variable among different populations of the species, possibly due to different ecological environments where they are growing. On the phylogenetic trees reconstructed from ITS and *trn*L-intron data (Koch & Al-Shehbaz, 2000), the plants from Hunan are distantly separated from those from Zhejiang, Jiangxi and Guangxi in the *Hilliella* clade. Further study is needed to clarify the relationship of the plants from these regions.

3.1.7 Hilliella rupicola (D. C. Zhang & J. Z. Shao) Y. H. Zhang in J. Wuhan Bot. Res. 8: 318. 1990. —— *Cochlearia rupicola* D. C. Zhang & J. Z. Shao in Acta Phytotax. Sin. 24: 404. 1986. —— *Yinshania rupicola* (D. C. Zhang & J. Z. Shao) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 91. 1998, syn. nov., p. p. excl. subsp. *shuangpaiensis* (Z. Y. Li) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo. Type: China. Anhui (安徽): Shitai (石台), Kuniujiang (牯牛降), Qimencha (祁门叉), 1150 m, 1983-06-29 (fl., fr.), J. Z. Shao 835008 (holotype, ANU!; isotype, NAS!).

石生泡果荠

Perennials, 30 – 70 cm tall, with a tuberous rhizome ca. 1 cm in diam., glabrous throughout. Stem erect, branched. Basal leaves 5 – 7-foliolate; stem leaves 3 – 5-foliolate; leaflet blades oblong-lanceolate or lanceolate, (1.5 –)2 – 5 × (0.5 –)0.8 – 2 cm, base oblique to cuneate or subtruncate, margin coarsely serrate with distinct mucros 0.5 – 1 mm at tooth apices, apex obtusely acuminate with a distinct mucro; petiolule 3 – 5 mm long; petiole 1.5 – 2.5 cm long; lateral leaflets slightly smaller than terminal leaflet. Upper stem leaves 3-foliolate, gradually becoming smaller and narrower upward. Racemes terminal and lateral, lowermost 1 – 3 flowers with simple and smaller bracteole. Sepals oblong, 1.5 – 2 mm long. Petals white, 3 – 4 × 2 – 3 mm. Anthers white, ellipsoid. Fruiting pedicel filiform, recurved, 5 – 7(– 10) mm long. Fruit narrowly obovate, conspicuously flattened parallel to replum, 4 – 6 × 2 – 2.5 mm; juvenile valves with minute pustules. Style to 2 mm long in fruit. Seeds 2 or 3. Fl. May. Fr. Jun. – Jul.

Additional specimens examined. **China. Anhui** (安徽): Xiuning (休宁), 1000 m, 1983-07-10 (fr.), J. Z. Shao 1154 (ANUB).

Distribution and habitat: Anhui. In wet shady places, forests, rocky crevices; 1000 m.

3.1.8 Hilliella shuangpaiensis Z. Y. Li in Acta Bot. Yunnan. 10: 117. 1988. —— *Yinshania rupicola* (D. C. Zhang & J. Z. Shao) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo subsp. *shuangpaiensis* (Z. Y. Li) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 92. 1998, syn. nov. Type: China. Hunan (湖南): Shuangpai (双牌), Majiang (麻江), Tongzishan (桐子山), 1000 m, 1986-09-22 (fl., juv. fr.), C. L. Liao 1439 (holotype, HUTM!).

Hilliella xiangguiensis Y. H. Zhang in Acta Bot. Yunnan. 19: 139. 1997. Type: China. Hunnan (湖南): Suining (遂宁), Huangshuang Xiang (黄双乡), Chibancun (赤板村), Laolongtan (老龙潭), 1700 m, 1985-07-17 (fr.). C. Z. Yuan 319 (holotype, HUTM!).

双牌泡果荠

Perennials, 30 – 100 cm tall or over, with a thick tuberous rhizome to 4 cm wide, glabrous throughout. Stem from rhizome, erect, branched above. Basal leaves 5 – 7(– 9)-foliolate; leaflets oblong or oblong-ovate 3 – 9.5 × 2 – 4.5 cm, with lateral nerves 5 – 9 pairs, base oblique, broadly cuneate, margin coarsely serrate, with distinct mucros at tooth apices, apex obtusely acuminate, with a distinct mucro; petiolule (0.5 –)1 – 2.5 cm long; petiole (8 –)15 – 20 cm long. Stem leaves 5 – 7-foliolate, gradually becoming smaller and narrower upward; petiolule short to 1 cm; petiole 1 – 3 cm long. Racemes terminal and lateral, many flowered. Fruiting pedicel filiform, recurved, 3 – 7 mm long. Sepals oblong, 1.8 – 1.9 × 0.7 – 0.9 mm. Petals white or pink, oblong, 1.5 – 2 × 0.9 – 1.3 mm long, base shortly clawed. Filaments white, 1 – 1.5 mm long; anthers oblong, ca. 0.5 mm long. Fruit orbicular to broadly obovate, distinctly flattened parallel to replum, 3 – 4 × 2.8 – 4 mm. Style 0.5 – 1(– 1.2) mm long. 2n = 44. Fl. May – Sep. Fr. Jun. – Oct.

Additional specimens examined. **China. Fujian** (福建): Chongan (崇安), Wuyingshan Pl. Exped. 2233 (IBSC). **Guangxi** (广西): Quan Xian (全县), T. X. Zhong 82026 (PE). **Hunan** (湖南): Hengshan (衡山), S. Q. Chen 3397 (MO, PE), S. F. Wu s. n. (ZJMA); Suining (遂宁), C. Z. Yuan 959 (HUTM). **Jiangxi** (江西): Jinggangshan (井冈山), S. S. Lai 660507 (LBG). **Sichuan** (四川): no locality, cultivated from seeds, Murata & Mizuno s. n. (KUN). **Zhejiang** (浙江): Qingyuan (庆元), B. Y. Ding et al. 3892 (HZU).

Distribution and habitat: Fujian, Guangxi, Hunan, Jiangxi, Sichuan and Zhejiang. In wet places, forests, valleys, along streams; 700 – 1700 m.

H. shuangpaiensis is related to *H. rupicola* on the basis of their thick tuberous rhizome and similar leaves. This is also supported by the result shown in the *trn*L-phylogenetic tree (but not by that in the ITS-phylogenetic tree, Koch & Al-Shehbaz, 2000). Al-Shehbaz et al. (1998) reduced *H. shuangpaiensis* Z. Y. Li to a subspecies of *H. rupicola*. However, *H. shuangpaiensis* has flowers with petals up to 2 mm long, orbicular fruits with style 0.5 – 1(1.2) mm long and the basal leaves with 9 (rare 7) leaflets. *H. rupicola* has flowers with petals up to 3 mm long, narrowly obovate fruits with style ca. 2 mm long and the basal leaves with 5 – 7 leaflets. These differences should keep *H. shuangpaiensis* at species rank rather than at subspecies rank.

3.1.9 Hilliella changhuaensis Y. H. Zhang in Acta Bot. Yunnan. 9: 155, fig. 2. 1987.

昌化泡果荠

Annuals or biennials with shorter rhizome, 60 – 110 cm tall. Stems erect, glabrous or puberulent. Basal and lower stem leaves 3 – 5-foliolate; leaflet blade lanceolate, (2.5 –)4 – 7.5 × 1.3 – 2.8 cm, terminal ones usually larger than the laterals, broadly obovate, (2.5 –)7 – 9.5 × 1.5 – 3.3 cm, base cuneate to rounded or oblique, margin serrate to irregularly dentate, distinctly mucronate, apex long acuminate or caudate with a mucro; leaflet blade with simple and obtuse trichomes 0.05 – 0.09(– 0.13) mm long on abaxial surface of the leaf and on veins of adaxial surface of leaf; petiolule 1 – 3 mm long; petiole 1 – 7 cm long, usually narrowly winged. Upper stem leaves 3-foliolate. Uppermost leaves simple or rarely 3-foliolate, similar to leaflets of lower leaves. Racemes terminal and lateral. Fruiting pedicel straight, 2 – 3 mm long, erect-ascending. Sepals

oblong, 2 – 2.5 mm long, sometimes puberulent. Petals white, spatulate, 2.5 – 4.5 × 1 – 1.2 mm. Fruit obovoid, oblong-ovoid to ellipsoid, rarely oblong, 3 – 5 × 2 – 3.8 mm. Style 0.5 – 1 mm. Seeds 2 – 3. 2n = 42.

3.1.9a var. **changhuaensis**

Cochlearia changhuaensis (Y. H. Zhang) L. L. Lu in Bull. Nanjing Bot. Gard. Mem. Sun Yat Sen: 17. 1991 (fr.), syn. nov., p. p. excl. syn. *H. guangdongensis* Y. H. Zhang. Type: China. Zhejiang (浙江): Lin'an (临安), Changhua, 1957-06-17, X. Y. He 23624 (holotype, NAS!; isotype, PE!).

Cochlearia alatipes auct. non Hand.-Mazz.: Zhang & Shao in Fl. Anhui 445. 1987.

Plant with shorter horizontal rhizome. Infructescence shorter, becoming densely paniculate. Terminal leaflet usually slightly lobed. 2n = 42. Fl. May – Jun. Fr. Jun. – Sept.

Additional specimens examined. **China. Anhui** (安徽): Huangshan (黄山), J. Z. Shao 810105 (PE), J. Z. Shao (84) 785335 (ANUB), S. F. Wu s. n. (SHCT), S. X. Wang 95001 (ZJMA). **Jiangxi** (江西): Wuning (武宁), S. S. Lai 2825 (KUN, LBG, PE). **Zhejiang** (浙江): Jinhua (金华), ZHU team (杭大采集队) 0014108, ZHU team (杭大采集队) 0014498 (ZHU); Lin'an (临安), M. B. Deng 4773 (PE), B. Y. Ding 1566 (HZU), B. L. Chiu 449 (MO).

Distribution and habitat: Anhui, Zhejiang. Along mountain streamsides, wet places; 500 – 800 m.

3.1.9b var. **longistyla** (Y. H. Zhang) Y. H. Zhang, st. et comb. nov. —— *Hilliella longistyla* Y. H. Zhang in Acta Bot. Yunnan. 9: 153. 1987. —— *Cochlearia longistyla* (Y. H. Zhang) L. L. Lu in Bull Nanjing Bot. Gard. Men. Sun Yat Sen: 18. 1991 (fl., fr.), syn. nov. Type: China. Zhejiang (浙江): Longquan (龙泉), 1919-06-03 (fl., fr.), H. H. Hu s. n. (holotype, ZM!).

长柱泡果荠 改级新组合

Inflorescence longer and loose. Fruit long obovate with longer style ca. 2 mm long. Fl. Apr. – Jun. Fr. May – Jul.

Additional specimens examined. **China. Jiangxi** (江西): Ji'an (吉安), Anonymous (70) 227 (PE); Xingzi (星子), X. Q. Wang 82103 (NAS), J. L. Wang et al. 81132 (LBG). **Hunan** (湖南): Huaihua (怀化), X. G. Li 203222 (HNNU).

Distribution and habitat: Jiangxi and Zhejiang. Mountain roadsides.

3.1.9c var. **lichuanensis** (Y. H. Zhang) Y. H. Zhang, st. et comb. nov. —— *Hilliella lichuanensis* Y. H. Zhang in Acta Bot. Yunnan. 9: 158. 1987. —— *Cochlearia lichuanensis* (Y. H. Zhang) L. L. Lu in Bull. Nanjing Bot. Gard. Mem. Sun. Yat Sen: 17. 1991. —— *Yinshania lichuanensis* (Y. H. Zhang) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 90. 1998, syn. nov. Type: China. Jiangxi (江西): Lichuan (黎川), M. X. Nie & S. S. Lai 2831 (holotype, PE!; isotypes, IBSC! KUN! LBG! SHM!).

黎川泡果荠 改级新组合

Plant robust up to 1 m tall or more. Petals 4.5 – 5 mm long. Sepal and style sometimes having trichomes. Infructescence loose, 8.5 – 12 cm long. Silicule oblong or obovate-ellipsoid ca. 5 mm long. Fl. May – Jun. Fr. Jun. – Aug.

Additional specimens examined. **China. Fujian** (福建): Shunchang (顺昌), M. S. Li & Z. Y. Li 4454 (PE), 4516 (PE). **Jiangxi** (江西): Lichuan (黎川), M. B. Deng et al. 87301 (NAS); Taihe (泰和), S. S. Lai 592 (LBG).

Distribution and habitat: Fujian and Jiangxi. In wet valleys, shady woods, or along streamsides. 450 – 500 m.

3.1.9d var. **guangdongensis** (Y. H. Zhang) Y. H. Zhang, st. et comb. nov. —— *Hilliella guangdongensis* Y. H. Zhang in Acta Bot. Yunnan. 9: 157. 1987, syn. nov. Type: China. Guangdong (广东): Renhua (仁化), L. Deng 7298 (holotype, PE!; isotype, IBSC!).

广东泡果荠 改级新组合

Stem shorter, ca. 0.5 m long. Leaves smaller, 2.5 – 7.5 × 2.8 mm. Silicules obovate, ca. 3 mm long; valves reticulate; style shorter ca. 1.5 mm long in fruit. Fl. before Jun. Fr. Jul. – Aug.

Distribution and habitat: Only found in Guangdong. Along streamsides.

In my previous work these three varieties, var. *longistyla*, var. *lichuanensis* and var. *guangdonghuaensis* were treated as three species (Zhang, 1987b). Al-Shehbaz et al. (1998) reduced *H. changhuaensis*, *H. longistyla*, *H. guangdongensis* to synonymy of *H. lichuanensis*. This encouraged me to more carefully reexamine this group of plants. The results have shown that it is not practical to treat them as only one species though they are closely related to each other. The above discussions have clearly shown that these three varieties are different from the typical variety, var. *changhuaensis*. Moreover, these three varieties also differ from each other in their morphological, biological and ecological characters. For example, var. *changhuaensis* has stomata on epidermis of both sides of leaves with 220/mm^2 or less whereas var. *longistyla* has the stomata only on the abaxial side of leaves with 371/mm^2 or more (Wei & Zhou, 1998). Besides, both *H. changhuaensis* and *H. longistyla* have different types of anticlinal and periclinal cell walls of the abaxial epidermal cells. On the phylogenetic tree of ITS and *trn*L-intron (Koch & Al-Shehbaz, 2000) *H. changhuaensis* and *H. lichuanensis* are different, though closely related, while *H. guangdongensis* is far distant from any of them.

The variations in *H. changhuaensis* seem to relate to their distributions. Var. *changhuaensis* is growing in the northern part of the distribution region of these plants, from Huangshan of Anhui and Lin'an of Zhejiang to Wuning of Jiangxi, between 29°2′ – 30°2′ N. The variety has a denser inflorescence, broadly obovate leaves with slightly lobed terminal leaflet. *H. changhuaensis* var. *longistyla* is found from Xingzi of Jiangxi to Ji'an of Jiangxi, Longquan of Zhejiang and Huaihua of Hunan, between 27°2′ – 29°5′ N. The variety differs from other varieties in having stem leaves with lanceolate leaflet and acuminate-caudate apex, long-obovoid fruits and longer style. *H. changhuaensis* var. *lichuanensis* occurs in Lichuan and Taihe of Jiangxi and Shunchang of Fujian,

between 26°8′ – 27°3′ N. The plants are characterized by having larger flowers, puberulent inflorescence rachis and pedicels, and fruit pedicel pressed close to the rachis. *H. changhuaensis* var. *guangdongensis* is growing in Renhua of Guangdong at about 25° N that is the southern limit of distribution for *H. changhuaensis*. These plants have smaller leaves and fruits than the others.

Due to these differences the treatment of these plants as one species, as Al-Shehbaz et al. (1998) suggested, is rejected here. They are recognized as varieties instead in this paper.

3.1.10 Hilliella yixianensis Y. H. Zhang in Acta Phytotax. Sin. 33: 94. 1995. —— *Yinshania yixianensis* (Y. H. Zhang) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 84. 1998, syn. nov. Type: China. Anhui (安徽): Yi Xian (黟县), Hongtan Xiang (宏潭乡), Hedongcun (河东村), 1993-05-18 (fl., fr.), Y. H. Zhang 93012 (holotype, PE!), from seed coll. by S. S. Qian in Hedongcun in 1991.

黟县泡果荠

Annuals or biennials. Stems erect, 40 – 90 cm tall, glabrous or rarely puberulent with short simple trichomes 0.06 – 0.1(– 0.15) mm long on both sides of leaves, sometimes trichomes like hispidulous hairs on node. Basal and middle stem leaves with 2 – 3 pairs of lateral leaflets, puberulous on adaxial surface, rarely on abaxial surface. Terminal leaflet long elliptic or ovate-lanceolate, 3 – 4 × 1 – 1.7 cm, base cuneate, margin obtusely dentate with distinct tooth mucro, apex acute with mucro; lateral leaflets ovate to elliptic, 1 – 2.5 × 0.8 – 1.2(– 2) cm, base obtuse to cuneate or oblique, margin obtusely dentate with minute mucros; petiolule 1 – 5 mm long; petiole 10 – 18 mm long. Upper stem leaves with 1 – 2 pairs of lateral leaflets; terminal leaflet oblong-lanceolate, 8 – 30 × 3 – 10 mm; lateral leaflets ovate, 4 – 14 × 2 – 8 mm. Racemes terminal and lateral, elongated to 22 cm in fruit; rachis conspicuously flexuous, slender. Fruiting pedicels slender, 5 – 6 (– 7) mm long, sometimes puberulent with short simple trichomes. Sepals elliptic, 1.3 – 1.5 × ca. 0.5 mm. Petals white, ovate, 1.5 – 2.5 × 0.8 – 1.5 mm, base shortly clawed. Fruit subglobose-obovoid 2.8 – 3.5 × (1.4 –) 2 – 2.2(– 2.5) mm. Seeds 1 – 3 × 1.5 – 2 mm. 2n = 42. Fl. Apr. – May. Fr. May – Jul.

Additional specimens examined. **China. Anhui** (安徽): Yi Xian (黟县), S. X. Qian 19003 (Medical Research Institute, Shanghai Railway Medical College), Y. H. Zhang 95001 (HHBG, HZU, NAS, ZJMA).

Distribution and habitat: Anhui. On roadsides of mountain foot.

Al-Shehbaz et al. (1998) indicated that *H. yixianensis* is closely related to *Y. acutangula* but they did not provide any evidence in support of this. In fact, *H. yixianensis* is quite different from *Y. acutangula* morphologically. And on the phylogenetic trees reconstructed from ITS and *trn*L-intron data *H. yixianensis* and *Y. acutangula* are distant from each other, the former being in the clade of the *Yinshania* group whereas the latter being in the clade of *Hilliella* group (Koch & Al-Shehbaz, 2000).

3.1.11 Hilliella paradoxa (Hance) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 404. 1986. —— *Cardamine paradoxa* Hance in J. Bot. 6: 111. 1868. —— *Cochlearia paradoxa*

(Hance) O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 8: 546. 1923. ——*Yinshania paradoxa* (Hance) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 567. 1992, syn. nov. Type: China. Guangdong (广东): Kai-kunshek, 1867-05-27 (fl., fr.), Sampson 13844 (holotype, K!; isotypes, GH, K, LE, P, W).

奇异泡果荠

Annuals or biennials, 30 – 100 cm tall, stem 3(– 4) mm in diam., glabrous throughout or rarely puberulent with minute simple trichomes to 0.07 mm long on abaxial surface of leaf. Stems erect or decumbent, 3(– 4) mm in diam., angled, simple or branched above. Basal and lowermost stem leaves 3- or very rarely 5-foliolate; leaflet blade ovate, oblong or lanceolate, 1.5 – 6 × 1 – 3 cm, base subtruncate, cuneate or obtuse, usually oblique, margin crenate or repand with callous mucros terminating at vein tips, apex obtuse to acute and mucronate; petiolule 0.2 – 1.5(– 2) cm long, longer on terminal leaflets; petiole 2 – 8 cm long. Racemes terminal and lateral; rachis straight, rarely irregularly twisted apically. Pedicel (1.5 –)2 – 3(– 4) mm long in fruit, straight, widely spreading, usually vertical to rachis. Sepals oblong, 2 – 2.3 × 0.8 – 1.0 mm. Petals white, spatulate, (2.3 –)2.5 – 3 × 0.8 – 1.0 mm. Fruit unequally obovoid to ellipsoid, 3 – 4(– 5) × 2.0 – 2.5(– 3) mm, usually oblique. Valves glabrous. Seeds 2 or 3, (1.5 –)1.7 – 2.0 × ca. 1 mm. 2n = 42. Fl. Apr. – Sep. Fr. May – Dec.

Additional specimens examined. **China. Guangdong** (广东): Xinghua (兴华), Shi 12525 (IBSC). **Guangxi** (广西): Dayaoshan (大瑶山), Li 400189 (IBSC). **Zhejiang** (浙江): Qingyuan (庆元), M. Q. Wu s. n. (NAS). **Sichuan** (四川): Chongqing (重庆), Q. H. Xiong et al. 1773 (PE), 3226 (PE), S. F. Wu & Z. G. Cai 9221 (ZJMA).

Distribution and habitat: Guangdong, Guangxi, Hubei, Zhejiang and Sichuan; N Vietnam (Zhou et al., 2001). On mountain slopes, valleys, roadsides, wet forests; 300 – 1000 m.

Al-Shehbaz et al. (1998) believed that *H. paradoxa* is most closely related to *H. rivulorum*. In fact, they are considerably different in many features. *H. paradoxa* has obovoid or ellipsoid fruits with 2 – 3 seeds, shorter style 0.5 – 0.8 mm long, fruiting pedicels (1.5 –)2 – 3(– 4) mm long and seeds 1.5 – 2 mm long, whereas *H. rivulorum* has narrowly oblong fruits with 7 – 10 seeds, style (1.0 –)1.5 – 2 mm long, fruiting pedicels 4.5 – 6(– 10) mm long, and seeds 0.8 – 1 mm long. Besides, *H. paradoxa* is a bigger plant, usually 30 – 70 cm tall, sometimes up to 1 m whereas *H. rivulorum* is a small plant, less than 22 cm tall.

3.2 *Yinshania* Y. C. Ma & Y. Z. Zhao in Acta Phytotax. Sin. 17: 113. 1979; Z. X. An in Fl. Reip. Pop. Sin. 33: 451. 1987; Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 563. 1992, p. p. quoad sect. *Yinshania* and sect. *Hilliella* (O. E. Schulz) Y. Z. Zhao ser. *Henryanae* Y. H. Zhang; Ying & Zhang, Endemic Gen. Seed Pl. China 238. 1994; Al-Shehbaz et al. in Harvard Pap. Bot. 3: 79. 1998, p. p. excl. syn. *Cochleariella* Y. H. Zhang & R. Vogt (as *Cochleariopsis* Y. H. Zhang), *Hilliella* (O. E. Schulz) Y. H. Zhang & H. W. Li et *Cochlearia* L. sect. *Hilliella* O. E. Schulz. Type: *Yinshania albiflora* Y. C. Ma & Y. Z. Zhao

(= *Y. acutangula* (O. E. Schulz) Y. H. Zhang).

阴山荠属

Annual herbs, sparsely to densely hairy, rarely glabrous; trichomes simple, furcate, or bifurcate. Stem erect and striate. Leaves pinnatipartite or pinnatisect, rarely compound or towards lower part compound. Inflorescences corymbose racemes, elongated in fruit, ebracteate; rachis straight or flexuous. Pedicel spreading in flower and straight or slightly recurved in fruit. Sepals oblong, spreading. Petals white or pinkish, obovate, base cuneate or becoming short claw, apex rounded. Filaments white, anthers elliptic-cordate or ellipsoid. Lateral nectar glands in pairs, ovoid-triangular; median ones absent. Ovary globose or oblong, with ovules 4 – 22. Silicules dehiscent, oblong, lanceolate-ellipsoid or nearly globose; valves convex, smooth or pustulate; false septum complete or fenestrate. Style distinct; stigma small, depressed-capitate. Seeds ovate, slightly flattened, 0.5 – 1 × 0.5 – 0.8 mm, reticulate, with clear ridges and meshes; cotyledons accumbent or incumbent.

The fruits of sect. *Yinshania* are lanceolate-ellipsoid, whereas they are subglobose to broadly ovoid in sect. *Microcarpa*. Reexamination of all collections of this genus reveals that this difference is constant. Therefore, it is reasonable to delimit these two sections based on the difference in the fruits.

In previous work (Zhang, 1987a), the sect. *Yinshania* was divided into two series, ser. *Henryanae* (infructescence rachis flexuous, trichomes dense) and ser. *Yinshania* (infructescence rachis straight, trichomes sparse or absent). This division was challenged by discovery of a new species, *Y. exiensis* Zhang (Zhang, 1993), which resembled ser. *Henryanae* in having the flexuous infructescence rachis and ser. *Yinshania* (especially *Y. acutangula*) in having a similar leaf shape. Moreover, there were only a few species in each series, so the infrasectional subdivision is not necessary and is abandoned in this paper.

It seems that Al-Shehbaz et al. (1998) over-emphasized the importance of trichomes when they delimited infrageneric taxa. For example, they treated *Cochlearia microcarpa* Kuan and *Cochlearia henryi* (Oliv.) O. E. Schulz var. *wilsonii* O. E. Schulz as two subspecies of *Y. acutangula*, based on these taxa all having longer simple trichomes. But, the three species are very different in their leaves and *Y. acutangula* has oblong fruits whereas the other two have subglobose fruits. Therefore, it would be better to keep them as three separate species. In another example, Al-Shehbaz et al. (1998) merged three species, *Y. zayiiensis* Y. H. Zhang, *Y. exiensis* Y. H. Zhang and *Y. ganluoensis* Y. H. Zhang into one, on the grounds that they all have furcate trichomes. In fact, these three species can be easily separated by the fruits, rachis shapes of inflorescence and other features. There will be more discussion about this under each species.

Two sections including eight species and two varieties are recognized in this genus.

Key to the taxa of *Yinshania*

1. Fruit oblong, oblong-ovoid or lanceolate-ellipsoid, 1.5 – 4.5 × 0.3 – 1.5 mm, with ratio of length to width 2.5 – 3.3 (section 1. *Yinshania*).
   2. Trichomes simple or absent.

3. Infructescence rachis straight; leaves usually pubescent, rarely glabrous ····· 3.2.1 **Y. acutangula**

3. Infructescence rachis conspicuously flexuous; leaves canescent, densely villous ····· 3.2.2 **Y. henryi**

2. Trichome branched.

4. Infructescence conspicuously flexuous.

5. Leaves pinnately compound ····· 3.2.3 **Y. furcatopilosa**

5. Leaves pinnatisect or pinnatipartite ····· 3.2.4 **Y. exiensis**

4. Infructescence rachis straight ····· 3.2.5 **Y. zayüensis**

6. Sepals 1 – 1.5 mm long, shorter than petals; seed 0.8 – 1 mm long ····· 3.2.5a var. **zayüensis**

6. Sepals 1 – 1.1 mm long, slightly longer than petals; seed ca. 0.55 mm long ····· 3.2.5b var. **gobica**

1. Fruit subglobose or broadly ovoid, 1 – 2.2 × 0.8 – 2.2 mm, with ratio of length to width ca. 1.1 (section 2. **Microcarpa** Y. H. Zhang).

7. Plant with simple trichomes; fruiting pedicels 4 – 5 mm long.

8. Racemes 18 – 20 cm long in fruit; lateral lobes of upper stem leaf larger, oblong or oblong-ovate, base rounded, cuneate or broadly cuneate, apex obtuse-rounded or slightly obtuse ····· 3.2.6 **Y. microcarpa**

8. Racemes 1.5 – 5.5(– 13) cm long in fruit; lateral lobes of upper stem leaf smaller, oblong-lanceolate, base cuneate, apex acuminate ····· 3.2.7 **Y. qianningensis**

9. Lateral infructescence with few (< 4) or no flowers ····· 3.2.7a var. **qianningensis**

9. Lateral infructescence with many (> 15) flowers ····· 3.2.7b var. **brachybotrys**

7. Plant with furcate trichomes; fruiting pedicels ca. 8 mm long ····· 3.2.8 **Y. ganluoensis**

Sect. 1. **Yinshania.** Zhang in Acta Phytotax. Sin. 25: 213. 1987; Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 565. 1992, p. p. quoad *Yinshania* sect. *Yinshania* ser. *Yinshania* & sect. *Hilliella* (O. E. Schulz) Y. Z. Zhao ser. *Henryanae*.

阴山荠组

Silicules oblong, oblong-ovoid, or lanceolate-ellipsoid, 1.5 – 4.5 × 0.3 – 1.5 mm, with ratio of length to width 2.5 – 3.3.

Five species and one variety are recognized in this section.

3.2.1 Yinshania acutangula (O. E. Schulz) Y. H. Zhang in Acta Phytotax. Sin. 25: 217. 1987. —— *Cochlearia acutangula* O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 10: 554. 1929. Type: China. Shaanxi (陕西): Miao-nan-san (妙南山), Pao-ki-seen (宝鸡寺), 1898-10 (fr.), G. Giraldi 2423 (holotype, B!).

Y. albiflora Ma & Y. Z. Zhao in Acta Phytotax. Sin. 17: 114. 1979. —— *Y. acutangula* (O. E. Schulz) Y. H. Zhang var. *albiflora* (Ma & Y. Z. Zhao) Y. H. Zhang in Acta Phytotax. Sin. 25: 217. 1987, syn. nov. Type: China. Nei Mongol (内蒙古): Daqingshan (大青山), 1971-08-19 (fl., fr.), Y. Z. Zhao 155 (holotype, HIMC!).

Y. wenxianensis Y. H. Zhang in Acta Phytotax. Sin. 25: 215. 1987, syn. nov. Type: China. Gansu (甘肃): Wen Xian (文县), Tielou, 1400 m, 1958-11-07 (fl., fr.), Y. Q. He 989 (holotype, PE!; isotype, PE!).

Y. wenxianensis Y. H. Zhang var. *songpanensis* Y. H. Zhang in Acta Phytotax. Sin. 25: 212. 1987, syn. nov. Type: China. Sichuan (四川): Songpan (松潘), Erdaoqiao (二道桥),

1800 m, 1937-10-22, K. T. Fu 2177 (holotype, PE!; isotype, WUG!).

阴山荠

Annuals, 30 – 60 cm tall. Stems angled or subterete, branched, sparsely pubescent. Leaves pinnatisect or pinnatipartite, with 1 – 4 pairs of lateral lobes, pubescent with subappressed simple straight trichomes (0.2 –)0.3 – 0.4(– 0.5) mm long, rarely glabrous. Leaf blade usually ovate, oblong or broadly ovate, 1 – 3.5 × 0.7 – 2 cm. Lower or middle leaves larger; terminal lobes ovate or oblong, 8.0 – 24 × 7.0 – 16 mm, usually deeply 3-lobed; lateral lobes 4 – 15 × 2 – 8 mm, shallowly lobed to entire, apex obtuse, usually with an indistinct minute tip; lobes smaller below; petiole 1 – 2 cm long. Upper stem leaves similar to lower ones but gradually shorter upward. Racemes terminal and lateral, 30 – 50-flowered, elongated in fruit. Fruiting pedicel 4 – 6(– 8) mm long, straight, divaricate or slightly recurved, pubescent or glabrous. Sepals long elliptic, ca. 1.6 × 1 mm. Petals obovate, 1.8 – 2(– 3) × 0.5 – 0.9 mm. Fruit oblong or lanceolate-ellipsoid, (2.5 –)3 – 4 (– 5) × 1 – 1.5 mm; valves pustulate or smooth; style 0.4 – 0.5(– 0.8) mm long; septum complete, fenestrate or only a small septum at the replum margin. Seeds (2 –) 5 – 10 (– 12) per locule, oblong-ovate, 0.6 – 0.8(– 1) × 0.4 – 0.5(– 0.7) mm, reticulate. 2n = 14. Fl. Jul. – Aug. Fr. Aug. – Oct.

Additional specimens examined. **China. Gansu** (甘肃): Yuzhong (榆中), S. Y. He 6121 (PE); Lanzhou (兰州), Y. Q. He 5242 (PE). **Hebei** (河北): Wu'an (武安), S. Y. He 21252 (PE, BJTC), S. Y. He s. n. (PE), D. Hu s. n. (PE). **Nei Mongol** (内蒙古): Jiufengshan (九峰山), Pei et al. 81-110 (HIMC); Sartchy, David 2889 (P); Tumd Youqi (土默特右旗), Y. Z. Zhao s. n. (HIMC), Z. X. Yin s. n. (PE); Wulashan (乌拉山), Wendusu s. n. (HIMC), X. Y. Lei et al. 2035 (HIMC). **Ningxia** (宁夏): Alashan (阿拉山), W. Y. Xia 3969 (WUK). **Sichuan** (四川): Luding (泸定), Z. X. Xiong & B. Y. Liu 112074 (SZ). **Xizang** (西藏): Zayü (察隅), Z. M. Tan 88-7 (SZ); Lhorong (洛隆), Z. M. Tan 88-8 (SZ).

Distribution and habitat: Gansu, Hebei, Nei Mongol, Ningxia, Shaanxi, Sichuan, Xizang and Qinghai (Zhou et al., 2001). Mountain slopes, rock crevices, valleys, grass marshland, fields or among bushes, and roadsides; 900 – 4200 m.

Y. acutangula is widespread in the distribution region of *Yinshania* and quite variable morphologically. Reexamination of *Y. wenxianensis* var. *wenxianensis* and var. *songpanensis* reveals that they are almost identical to *Y. acutangula*, and are therefore reduced to synonymy of *Y. acutangula* in this paper.

3.2.2 Yinshania henryi (Oliv.) Y. H. Zhang in Acta Phytotax. Sin. 25: 213. 1987. —— *Nasturtium henryi* Oliv. in Hooker's Icon. Pl. 18: t. 1719. 1887. —— *Cochlearia henryi* (Oliv.) O. E. Schulz in Notizbl. Bot. Gart. Mus. Berlin-Dahlem 8: 546. 1923. Type: China. Hubei (湖北): Yichang (宜昌), A. Henryi 2899 (holotype, K!; isotype, K!).

Nasturtium kouytchense Lévl. in Bull. Soc. Agr. Sci. Art. Sarthe 31: 321. 1904. Type: China. Guizhou (贵州): environ de Gan-pin, 1897-09-20, L. Martin & E. Bodinier 1804

(holotype, E; isotype, P).

柔毛阴山荠

Annuals, 15 – 40(– 50) cm tall. Stems branched, terete. Lower and middle stem leaves 3 – 5(– 9)-foliolate, canescent, usually densely villous with straight, simple and flat trichomes (0.25 –)0.4 – 0.6(– 0.8) mm long; terminal leaflet blade broadly ovate to suborbicular, rarely narrowly ovate, 1.5 – 2.6 × 0.9 – 3.0 mm, base slightly cordate to subtruncate, margin 3-lobed, lobes deeply crenate, apex rounded; lateral leaflet blade 6 – 14 mm long, with margin shallowly crenate, base attenuate; petiolules 1 – 3(– 5) mm long to sessile; petioles 1.5 – 6 cm long. Upper stem leaves 3-foliolate or pinnatipartite to pinnatisect. Uppermost leaf usually simple, entire or shallowly 3-lobed. Racemes elongated in fruit; rachis slightly or strongly flexuous, at least apically. Pedicel slender, straight, spreading, 5 – 10(– 15) mm long in fruit, villous or rarely glabrous. Sepals oblong, 1.5 – 2 × 0.6 – 1.2 mm, usually villous outside. Petals white, obovate 2 – 3.5 × 1.1 – 1.7 mm, base shortly clawed, apex rounded. Fruit narrowly oblong to oblong-lanceolate or sublinear, (2.8 –)3.0 – 5.0 × 1 – 1.5 mm; valves villous or glabrous; septum complete or fenestrate. Seeds (2 –) 5 – 10 per locule. 2n = 12. Fl. and fr. Jun. – Sept.

Additional specimens examined. **China. Guizhou** (贵州): Bijie (毕节), P. Y. Yu 678 (KUN); Gan-pin, J. Esquirol 4348 (P); Suiyang (绥阳), B. Q. Zhong 429 (KUN). **Hubei** (湖北): Fang Xian (房县), Z. D. Jiang & G. F. Tao 383 (E, MO); Yichang (宜昌), A. Henry 4125 (B, E, GH, K, NY, P), H. J. Li 9409 (PE); Western Hubei, E. H. Wilson 1960 (K, NY, W); Shennongjia (神农架), M. Z. Liu 15748 (HIB), Y. Zhou 9107003 (ZJMA), M. Z. Liu 16014 (HIB). **Sichuan** (四川): Nanchuan (南川), Z. Y. Liu 13136 (ZJMA), 13082 (ZJMA); Q. H. Xong & Z. L. Zhen 91832 (IBSC, PE, SZ). **Yunnan** (云南): without precise locality, J. Cavalerie 690 (E, K).

Distribution and habitat: Guizhou, Hubei, Sichuan, and Yunnan. On dry rocky cliffs, dry valleys; 620 – 1300 m.

Yinshania henryi and *Y. microcarpa* have extremely varied leaves compared with other species in the genus. The middle and lower leaves usually have 3 – 5(– 9) leaflets, sessile or with petiolules 1 – 3(– 6) mm long while the upper leaves are usually pinnatipartite or pinnatisect.

Yinshania henryi is also widespread in the distribution region of *Yinshania*. It is most closely related to *Y. furcatopilosa*. Both of them have canescent leaves, especially in *Y. furcatopilosa*, and flexuous infructescence rachis.

3.2.3 Yinshania furcatopilosa (Kuan) Y. H. Zhang in Acta Phytotax. Sin. 25: 214. 1987. —— *Cochlearia furcatopilosa* Kuan in Bull. Bot. Lab. North-East. Forest. Inst. 8: 41. 1980. Type: China. Hubei (湖北): Shennongjia (神农架), Shennongjia Exped. 213320. (holotype, PE!; isotype, PE!).

叉毛阴山荠

Annuals, (5 –)10 – 15(– 25) cm tall, canescent, densely covered with forked and bifurcate trichomes. Stems erect, branched, terete. Basal and lower stem leaves 3 – 5-foliolate, canescent,

densely pubescent with bifurcate trichomes (0.12 –)0.23 – 0.4 mm long; terminal leaflet blade rhombic-ovate, oblong or subreniform, 0.6 – 1.5 × 0.4 – 1.6 cm, base subtruncate to rounded, margin lobed to crenate, apex rounded; lateral leaflet blade suborbicular to ovate, 3 – 6 × 2 – 7 mm, margin mostly entire; petiolule 1 – 2 mm long; petiole 1 – 2 cm long. Uppermost leaves simple, entire or lobed, pubescent. Racemes terminal becoming paniculate, rachis distinctly flexuous. Pedicel divaricate, straight, slender, 4 – 8(– 10) mm long in fruit, glabrous or pubescent at base. Sepals oblong, 1.2 – 1.5 × 0.8 – 0.9 mm, glabrous. Petals white, obovate, 3 – 3.2 × 1.6 – 2 mm, base shortly clawed, apex rounded. Fruit oblong, rarely subovate, 2 – 3 × 0.9 – 1.1 mm, valves glabrous or pubescent; septum complete or fenestrate. Seeds finely reticulate. 2n = 12. Fl. and fr. Jun. – Jul.

Additional specimens examined. **China. Hubei** (湖北): Shennongjia (神农架), PLA units-236-6 2598 (PE), Y. Zhou 9107001 (ZJMA), Shennongjia Exped. 21828 (PE), Sino-American Bot. Exped. to Hubei 685 (MO, PE).

Distribution and habitat: Hubei. Mountain slopes, rocky areas, roadsides; 800 – 1600 m.

3.2.4 Yinshania exiensis Y. H. Zhang in Acta Bot. Yunnan. 15: 364. 1993. Type: China. Hubei (湖北): Shennongjia (神农架), Xinhuaxiang (新华乡), Longkou (龙口), 1000 m, 1976-07-02 (fr.), Shennongjia Exped. 20597 (holotype, HIB!).

鄂西阴山荠

Annuals, 20 – 33 cm tall. Stem branched, puberulent with minute, sturdy, simple and furcate trichomes (0.05 –)0.06 – 0.09 mm long. Lower and middle stem leaves pinnatisect or pinnatipartite; leaf blade ovate or oblong-ovate, 3 – 6 × 2 – 2.5 cm; terminal lobe rhombic-ovate or oblong-ovate, 8 – 18 × 3 – 5 mm, base cuneate, margin broadly 1 – 2-serrate, apex acute; lateral lobes 3 – 4 pairs, oblong, elliptic or obovate, 7 – 10 × 2.5 – 6 mm, base cuneate, margin broadly 1 – 2-serrate or nearly entire, apex acute. Upper stem leaves progressively smaller upward; lateral lobes 2 – 4, lobes oblong or linear, 9 – 13 × 1.5 – 3 mm, puberulent with forked and bifurcate trichomes on abaxial surface of leaf and simple trichomes on adaxial surface of leaf; petiole (0.4 –)1.2 – 2.5 cm long. Racemes terminal or axillary; rachis conspicuously flexous, 6 – 10 cm in fruit; pedicels with furcate trichomes, 6 – 9 mm long in fruit. Sepals ca. 1.5 × 0.5 mm. Petals purple, ca. 2 mm long. Fruit oblong, 3 – 5 × 1 – 1.3(– 1.5) mm; septum complete. Seeds 5 – 6 per locule, ca. 1 × 0.5 mm. Fl. May. Fr. Jun. – Jul.

Additional specimens examined. **China. Hubei** (湖北): Guandu (官渡), S. X. Qian 7901875 (SG); Yichang (宜昌), Z. Zheng 1473 (HIB).

Distribution and habitat: Hubei. Mountain slopes, forests, roadsides.

3.2.5 Yinshania zayüensis Y. H. Zhang in Acta Phytotax. Sin. 25: 214. 1987; Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 84. 1988, p. p. excl. syn. *Y. exiensis* Y. H. Zhang et *Y. ganluoensis* Y. H. Zhang.

察隅阴山荠

Annuals, 20 – 60 cm tall. Stem branched, puberulent with forked trichomes 0.03 – 0.07

(-0.1) mm long. Leaves pinnatipartite; leaf blade oblong, 1.5-3.5×1-2.5 cm, puberulent with minute, sturdy, simple and forked trichomes; terminal lobe oblong or oblong-linear, 10-15×2.5-5 mm, base cuneate, margin broadly serrate to entire, apex acute; lateral lobes 1-2 pairs, oblong or obovate-oblong 5-15×1.5-3 mm, entire; petiole 2-7 mm long. Racemes terminal and axillary; rachis straight, 5-24 cm long in fruit; pedicels puberulent with simple and forked trichomes, 6-8 mm long in fruit. Sepals oblong, 1-1.5×0.5-0.7 mm. Petals 1.5-2×0.7-1.2 mm or slightly longer than sepals. Fruit oblong, (2-)3-4(-4.5)×(0.6-)0.8-1.2 mm; valves usually with simple and forked trichomes, or glabrous; septum complete. Seeds ca. 8 per locule, ovate, 0.5-1×0.6 mm.

3.2.5a var. **zayüensis**

Yinshania yunnanensis Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 565. 1992, non *Camelina yunnanensis* W. W. Smith. Type: China. Xizang (西藏): Zayü (察隅), Chawalong, 2800 m, 1935-08 (fr.), C. W. Wang 65236 (holotype, PE!; isotypes, IBSC!, PE!, WUK!).

Camelina yunnanensis auct. non W. W. Smith: Z. X. An in Fl. Reip. Pop. Sin. 33: 446, pl. 126, figs. 6-8. 1987.

Sepals 1-1.5 mm long, shorter than petals. Seeds 0.8-1 mm long. Fl. and fr. Jul.-Aug.

Additional specimens examined. **China. Yunnan** (云南): Dêqên (德钦), K. M. Feng 6329. (KUN, PE), J. S. Yang 8717 (KUN), C. W. Wang 65136 (A, KUN! PE!).

Distribution and habitat: Yunnan and Xizang. In forests and edges of woods; 2600-3000 m.

Yinshania zayüensis was misidentified as *Camelina yunnanensis* W. W. Smith in Flora Reipublicae Popularis Sinicae (An, 1987). Later Zhao (1992) discovered the misidentification but he made a new combination of *Yinshania yunnanensis* (W. W. Smith) Y. Z. Zhao. Unfortunately, *C. yunnanensis* was a synonym of *Rorippa globosa* (Turczaninow) Thellung (Wang, 1993) and Zhao's species *Yinshania yunnanensis* (W. W. Smith) Y. Z. Zhao was related to *Y. zayüensis* rather than *C. yunnanensis* W. W. Smith (= *R. globosa*). Therefore, in this paper Zhao's combination is listed as a synonym of *Y. zayüensis*, and the name of W. W. Smith is rejected.

3.2.5b var. **gobica** (Z. X. An) Y. H. Zhang, com. nov. —— *Y. albiflora* Y. C. Ma & Y. Z. Zhao var. *gobica* Z. X. An in Fl. Xinjiang. 2 (3): 381, pl. 64: 3-5. 1995, syn. nov. Type: China. Xinjiang (新疆): Wusu (乌苏), 1980-05-02 (fl.), W. H. Hou 008 (holotype, XJFA).

戈壁阴山荠 新组合

Sepals 1-1.1 mm long, longer than petals. Seeds smaller, ca. 0.5 mm long. Fl. Apr.-May.

Additional specimen examined. **China. Xinjiang** (新疆): known only from the type collection.

Distribution and habitat: Xinjiang. In Gobi desert.

This variety (An, 1995) is more closely related to var. *zayüensis* than to *Y. albiflora* (= *Y. acutangula*), due to its forked trichomes. The latter has simple trichomes and, therefore, a new combination of var. *gobica* was made here.

Al-Shehbaz et al. (1998) reduced *Y. exiensis* Y. H. Zhang and *Y. ganluoensis* Y. H. Zhang to the synonymy of *Y. zayüensis*, on the grounds that their stems and leaves all have furcate pubescence which is not found in any other species of *Yinshania*. However they are different from each other in many other respects. *Y. ganluoensis* differs from the other two by having subglobose or broadly ovoid fruit and narrowly forked trichomes with an angle smaller than 90° whereas the other two have oblong fruit and widely forked trichomes with an angle larger than 90°. *Yinshania exiensis* differs from *Y. zayüensis* in the following respects. *Y. exiensis* has a flexuous infructescence rachis, and flat forked trichomes (Fig. 4: B) on the abaxial surface of leaves and simple trichomes on the adaxial surface of leaves as well, whereas *Y. zayüensis* has a straight infructescence rachis, forked and simple trichomes (Fig. 4: A) on both sides of the leaves. Furthermore, *Y. exiensis* has longer petioles of stem leaf and wider furcate trichomes compared with *Y. ganluoensis*. They, therefore, are still recognized as separate species in this paper.

Sect. 2. **Microcarpa** Y. H. Zhang in Acta Phytotax. Sin. 25: 210. 1987. —— *Yinshania* sect. *Yinshania* ser. *Microcarpa* (Y. H. Zhang) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 566. 1992, syn. nov. Type: *Yinshania microcarpa* (Kuan) Y. H. Zhang.

小果组

Silicules subglobose or widely ovoid, 1 – 2.2 × 0.8 – 2.2 mm, with ratio ca. 1.1 of length to width.

Three species and one variety belong to this section.

3.2.6 Yinshania microcarpa (Kuan) Y. H. Zhang in Acta Phytotax. Sin. 25: 211. 1987. —— *Cochlearia microcarpa* Kuan in Bull. Bot. Lab. North-East Forest. Inst. 8: 40. 1980. —— *Y. acutangula* (O. E. Schulz) Y. H. Zhang ssp. *microcarpa* (Kuan) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 83. 1998, syn. nov. Type: China. Sichuan (四川): Gulin (古蔺), Taipingxiang (太平乡), Yuhuangdong, 1100 m, 1976-08-25 (fr.), Gulin Exped. 943 (holotype, PE!; isotype, SM!).

Annuals, 20 – 45 cm tall. Stems erect, branched, with leaves sparsely pubescent with simple straight trichomes (0.1 –)0.15 – 0.26 mm long. Lower stem leaves pinnate, with 3 – 4 pairs of lateral leaflets; terminal leaflet deeply or completely 3-lobed, with oblong lobes 2 – 3 cm long; lateral leaflets oblong-ovate, 1.5 – 2 cm long, base cuneate, margin deeply 1 – 3-serrate each side, apex rounded, lowermost smaller, entire; petiolule ca. 1 mm long; petiole 1 – 1.5 cm long. Upper stem leaves 3-foliolate or pinnatipartite to pinnatisect. Uppermost leaf simple, 4 – 8 mm long. Racemes terminal and lateral, 18 – 20 cm long in fruit. Fruit broadly ovoid to globose, 1 – 1.5 mm long; valves glabrous or pilose; pedicels 4 – 5 mm long in fruit; septum complete. Seeds ca. 4 per locule, 0.8 mm long. Fl. May – Jun. Fr. Jun. – Aug.

Additional specimens examined. **China. Sichuan** (四川): Baoxing (宝兴), Anonymous 78-

1088 (SM); Kangding (康定), Anonymous 066 (SM); Shimian (石棉), Anonymous 78-0402 (SM); Shizhu (石柱), Anonymous 0298 (SM).

Distribution and habitat: Sichuan. In bush lands, rocky crevices, dry caves; 1100 – 3600 m.

Al-Shehbaz et al. (1998) treated *Cochlearia microcarpa* and *Cochlearia henryi* (Oliv.) O. E. Schulz var. *wilsonii* O. E. Schulz as two subspecies of *Y. acutangula*. However, because their fruits are so different, the former two taxa are here placed in sect. *Microcarpa* and the latter in sect. *Yinshania*. According to molecular data (Koch, per. comm. 1988) *Y. acutangula* and *Y. qianningensis* were clustered in different clades of *Yinshania* lending support to the treatment proposed here.

3.2.7 Yinshania qianningensis Y. H. Zhang in Acta Phytotax. Sin. 25: 212. 1987. Type: China. Sichuan (四川): Qianning (乾宁), 3000 m, 1974-08-14 (fl., fr.), Anonymous 5822 (holotype, PE!; isotype, CDBI!).

Cochlearia henryi (Oliv.) O. E. Schulz var. *wilsonii* O. E. Schulz in Repert. Spec. Nov. Regni Veg. 38: 108. 1935. —— *Y. acutangula* (O. E. Schulz) Y. H. Zhang ssp. *wilsonii* (O. E. Schulz) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo in Harvard Pap. Bot. 3: 83. 1998, syn. nov. Type: China. Sichuan (四川): 4500 m, without date (fl., fr.), E. H. Wilson 3210 (holotype, BM!; isotypes A (photo!), K, P).

Y. acutangula auct. non. O. E. Schulz: Kuan in Fl. Reip. Pop. Sin. 33: 100. p. p. quoad pl. 23, figs. 1 – 3. 1987.

乾宁阴山荠

Annuals, 30 – 85 cm tall. Stems branched, erect, sparsely pubescent with simple trichomes, rarely glabrescent or glabrous. Basal and stem leaves pinnatisect or pinnatipartite, puberulent with simple trichomes (0.2 –)0.3 – 0.5(– 0.6) mm long; leaf blade ovate or oblong-ovate, (1.3 –)2 – 3.5 × (0.7 –)1.3 – 2.5 cm; terminal lobe ovate-triangular or oblong-ovate, deeply 3-lobed; lateral lobes 1 – 3 pairs, oblong-lanceolate, (5 –)8 – 18 × (1 –)1.5 – 7 mm, base cuneate, margin 1 – 5-serrate to entire, apex usually acuminate with a minute tip; petiole 1.5 – 10 mm long. Racemes terminal or lateral, 1.5 – 5.5(– 13) cm long in fruit. Pedicels 3 (– 4) mm long in fruit, straight, divaricate or vertical to rachis. Sepals obovate, 1 – 1.1 × ca. 0.5 mm. Petals white, 1.5 – 1.7 × ca. 0.8 mm. Fruit subglobose or broadly ovoid, 1.3 – 1.4 × (0.8 –)1.3 mm; valves nerved; septum complete. Seeds 3 – 4 per locule, 0.5 – 0.7 × ca. 0.4 mm. 2n = 12.

3.2.7a var. **qianningensis**

Lateral inflorescences not luxuriant, with only few (< 4) or no flowers. Fl. Jun. Fr. Jul. – Aug.

Additional specimens examined. **W China**: without locality and date, E. H. Wilson 3210a (A, P). **Sichuan** (四川): Kangding (康定), S. F. Wu & Z. G. Cai 9378 (ZJMA).

Distribution and habitat: Western China. Dry banks; 4500 m.

3.2.7b var. **brachybotrys** Y. H. Zhang in Acta Phytotax. Sin. 25: 212. 1987. Type: China. Gansu (甘肃): Wen Xian (文县), Caoheba, 1600 m, 1973-07-10 (fl.), J. X. Yang 3373

(holotype, PE!; isotypes, IBSC! WUG!).

短序阴山荠 变种

Lateral inflorescences very luxuriant with many (>15) flowers. Fl. and fr. to Oct.

Distribution and habitat: Gansu, on roadsides; ca. 1600 m.

Yinshania qianningensis differs from *Y. microcarpa* in having shorter inflorescence, 1.5 – 13 cm long in fruit, oblong-lanceolate leaf lobes usually with cuneate base and acuminate apex. The latter is charecterized by having longer inflorescence, 18 – 20 cm long in fruit, oblong or long ovate leaf lobes with roundly or broadly cuneate base and rounded-obtuse apex.

On the phylogenetic tree of nrDNA ITS and cpDNA *trn*L-intron (Koch & Al-Shehbaz, 2000) there are only four species: *Y. acutangula*, *Y. henryi*, *Y. furcatopilosa*, and *Y. qianningensis* included in the genus *Yinshania*. They all appeared as independent species. However, it is noteworthy that *Y. qianningensis* was nested within the *Hilliella* clade rather than the *Yinshania* clade in *trn*L-phylogeny whereas *Y. qianningensis* distinctly belongs to *Yinshania* morphologically. This was used as Al-Shehbaz et al.'s (1998) evidence for supporting the reduction of *Hilliella* as the synonymy of *Yinshania* sensu Al-Shehbaz et al. (1998). However, it is noteworthy that *Y. qianningensis* appeared in the *Hilliella* clade in the *trn*L-intron phylogeny when gaps were considered as additional unweighted binary characters, whereas when the gaps were considered as missing data the *Y. qianningensis* appeared in the *Yinshania* clade (Koch 1998, per. Comm.) and he said: "basically *Hilliella* seems to be a monophyletic group". Clearly, more research on *Y. qianningensis* is needed.

3.2.8 Yinshania ganluoensis Y. H. Zhang in Acta Phytotax. Sin. 25: 211. 1987. Type: China. Sichuan (四川): Ganluo (甘洛), Suxiong, 800 m, 1979-06-26 (fr.), Anonymous 556 (holotype, MS!; isotype, MS!).

甘洛阴山荠

Stem erect, ca. 25 cm tall or so, branched, puberulent with furcate, simple, slightly sturdy short trichomes 0.12 – 0.16 mm long. Leaves ovate or oblong-ovate, 1.5 – 4 × 1 – 3 cm, pinnatisect or pinnatipartite; terminal lobe oblong or oblong-ovate, 2 – 3 × 0.7 – 1.5 cm, base cuneate, margin irregularly lobed or deeply serrate, apex obtuse with a minute tip; lateral lobes 2 – 4, oblong, 5 – 25 × 1 – 6 mm, margin deeply 1 – 2-serrate to entire, lowermost with a pair smaller lobes, margin usually entire, base cuneate, apex obtuse. Petiole 0.3 – 1.3 cm. Racemes terminal, 4.5 – 10 cm long in fruit. Pedicels ca. 8 mm long in fruit, widely spreading. Fruit ovate-ellipsoid or broadly ovoid, 1.8 – 2.2 × 1.5 – 2 mm. Seeds 3 – 4 per locule. Fl. May. Fr. Jun.

Additional specimen examined. **China. Sichuan** (四川). Known only from the type collection.

Distribution and habitat: Sichuan. On roadside or river bank.

This species fits into section *Microcarpa* well because of its finely subglobose fruit. It is easily separated from the rest of the species in this section by its stem leaf having a larger terminal lobe; and stems, branches and leaves having furcate and shorter simple trichomes 0.12 – 0.16 mm long;

and racemes having fruiting pedicels ca. 8 mm long which are the longest in this section.

4 Excluded names

Cochlearia alatipes Hand.-Mazz., Symb. Sin. 7: 370. 1931. —— *Hilliella alatipes* (Hand.-Mazz.) Y. H. Zhang & H. W. Li in Acta Bot. Yunnan. 8: 402. 1986. —— *Yinshania alatipes* (Hand.-Mazz.) Y. Z. Zhao in Acta Sci. Nat. Univ. Intramongol. 23: 568. 1992. Type: China. Hunan (湖南): Wugang (武岗), Yun-schan (云山), 1000 m, 1918-06-12 (juv. fr.), Handel-Mazzetti 12097 (holotype, WU; isotypes, E, W, WU) = *Cardamine fragariifolia* O. E. Schulz (Al-Shehbaz & Yang, 1998).

Hilliella alatipes (Hand.-Mazz.) Y. H. Zhang & H. W. Li var. *macrantha* Y. H. Zhang in Acta Bot. Yunnan. 8: 403. 1986. Type: China. Yunnan (云南): Malipo (麻栗坡), Guangaw, 1000 m, 1940-02-14 (fl.), C. W. Wang et al. 86836 (holotype, KUN!; isotype, IBSC) = *Cardamine cheotaiyienii* Al-Shehbaz & G. Yang (1998).

5 Discussion

Since the publication of Al-Shehbaz et al.'s paper (1998) I have mulled over how to delimit *Hilliella* and *Yinshania*, the group of Chinese-endemic Brassicaceae. Because I have worked on this group of plants for a long time, I decided to reassess them to see which is the best way to delimit them. After careful reexamination I agree that *Cochleariella* could be a synonym of *Hilliella*, and appreciate some of the errors they pointed out in my previous work. For example, *Cochlearia fumarioides* Dunn was already published in 1908 but was renamed as *Cochleariopsis zhejiangensis* Y. H. Zhang (= *Cochleariella zhejiangensis* (Y. H. Zhang) Y. H. Zhang & R. Vogt) in 1985 because the type specimen was not available. *Cardamine fragariifolia* O. E. Schulz (Al-Shehbaz et al., 1998) was misidentified as *Cochlearia alatipes* Hand.-Mazz. (Handel-Mazzetti, 1931). *Hilliella alatipes* (Hand.-Mazz.) Y. H. Zhang & H. W. Li var. *macrantha* Y. H. Zhang should belong to *Cardamine*. Also *H. alatipes* var. *micrantha* Y. H. Zhang should be reduced to synonymy of *H. rivulorum* (Dunn) Y. H. Zhang & H. W. Li. But one thing I cannot agree with is that *Hilliella* and *Yinshania* should be recognized as a single genus.

The major reasons Al-Shehbaz et al. (1998) gave for treating these two genera as one is that they believe the differences between these two groups of plants are "inconsistent" (Al-Shehbaz et al., 1998).

One of the inconsistent differences mentioned by Al-Shehbaz et al. (1998) was that "reticulate seeds occur in both *Hilliella* and *Yinshania*". This is possibly caused by one of my misjudged illustrations (Zhang & Cai, 1989). In 1989 I illustrated some abnormal seeds of *H. changhuaensis*, which had thinner and irregularly reticulate seed coats rather than the tuberculate seed coats which are found in the normal seeds. This error was not redressed until more normal seeds were collected in 1995 in Huangshan of Anhui (S. X. Wang 95001). Unfortunately, this erroneous information was quoted by Zhao (1992) and Al-Shehbaz et al. (1998), and used as one of the reasons for

combining *Hilliella* and *Yinshania*. It was also unfortunate that, when *H. lichuanensis* Y. H. Zhang, *H. changhuaensis*, *H. longistyla* Y. H. Zhang and *H. guangdongensis* Y. H. Zhang were combined into *Yinshania lichuanensis* (Y. H. Zhang) Al-Shehbaz, G. Yang, L. L. Lu & T. Y. Cheo, the seeds of all above species were described as "reticulate" (Al-Shehbaz et al., 1998). In fact, the seeds of all the above four species have tuberculate seed coats rather than "reticulate". In their same paper the seed coat ornamentation of *Y. furcatopilosa* was described as "finely papillate" (Al-Shehbaz et al., 1998) whereas in fact it should be reticulate. Possibly, one of the reasons for their belief is my misleading illustration. Another reason, perhaps the most important, may be that they did not examine the ornamentations very carefully or ignored them totally, despite examining "a large number of specimens of the complex" (Al-Shehbaz et al., 1998).

The second reason given by Al-Shehbaz et al. for combining *Yinshania* and *Hilliella* is that "Only 2 of the 11 *Yinshania* species recognized by Zhang (1996a) have branched trichomes". Certainly, only some (five or four, not two) species of *Yinshania* have branched trichomes and the others have different simple trichomes. But as stated above, none of the *Hilliella* species have branched trichomes. In particular *Hilliella* has only one type of trichome, which is shorter and softer with obtuse or rounded apex, clearly different from all the trichome types in *Yinshania*.

The third of the inconsistent differences mentioned by Al-Shehbaz et al. (1998) is that " Some of the species described or maintained by Zhang (1986, 1987b) in *Hilliella* have fruits with complete septa", although they did not say which has such seeds. I have re-examined all the collections of all the species in *Hilliella*, and none of them have been found to have any kind of septa. Al-Shehbaz et al. (1998) also claimed that "As for the presence versus absence of septum, this feature is not useful at the generic rank, and septate and eseptate fruits occur within numerous genera of Brassicaceae." It is difficult to understand why they state this. Certainly, if both septate and non-septate fruits occur within a particular genus, then clearly one may not use this character to compare the genus with other genera. However, this does not mean that one should reject this character at the generic level in all other cases. Cronquist (1988) has pointed out that "obvious morphological characters of any sort do not have a fixed, inherent taxonomic significance. A character that distinguishes families in one order may distinguish genera in another family, or species in another genus, or it may vary on a single individual of another species". This means that in each case the taxonomic importance of the character can only be determined after all the relevant groups have been examined. Ideally the character should correlate with other morphological characters so that a group can be satisfactorily defined and delimited, although taxonomic groups must be primarily based on discontinuities in characters or character states. And it is important that any attempt to do a truly natural classification should neglect no evidence and should be based on as many attributes as possible. Al-Shehbaz himself used the septum as a character for differentiating a new genus and new species in the taxonomic study of *Dactylocardamum imbricatifolium* (Al-Shehbaz, 1989). In Vol. 8 of the Flora of China, the chapter on Brassicaceae (Cruciferae) (Zhou et al., 2001) has been written by the same authors as those of Al-Shehbaz et al.'s paper (1998). Zhou et al. (2001) stated that

"Fruit characters are essential in the identification of genera". I wonder why in the delimitation of *Yinshania and Hilliella* this feature which "is not useful at the generic rank" is mentioned as "essential" by the same authors in a later publication (Zhou et al., 2001).

Another reason given by Al-Shehbaz et al. (1998) for combining *Yinshania* and *Hilliella* is that "Finally, both compound and pinnatisect leaves are found within *Yinshania*, and as delimited by Zhang (1986), *Hilliella* included species with simple or compound leaves." The leaves of *Hilliella* and *Yinshania* are indeed variable and are not as consistent as the above-mentioned characters. However, all of the *Hilliella* species except *H. sinuata* (Kuan) Y. H. Zhang & H. W. Li have compound leaves. In contrast, all *Yinshania* species have simple leaves which are predominantly pinnatisect to pinnatipartite, except for *Y. furcatopilosa*, *Y. microcarpa* (Kuan) Y. H. Zhang and *Y. henryi* (Oliv.) Y. H. Zhang by having various leave types. These differences are real and quite consistent or natural. However, it should be borne in mind that the consistency of a character is always relative, and that some degree of variation is to be expected in the natural world. As Zhou et al. (2001) have stated, "The delimitation of genera in the Brassicaceae is often difficult because of the frequent independent evolution of what appear to be similar character states, the variability of a given character in one genus and its fixture in another". It is well known that leaves are one of the characters which are very variable in this family and others. With regard to the leaves of *Hilliella* and *Yinshania*, sometimes it is even difficult to determine whether the leaves are pinnatisectly simple or pinnately compound in *Yinshania*. This difficulty can cause confusion or misjudgment in examination of the leaves of these two groups of plants.

This study has shown that there are clear differences between *Hilliella* and *Yinshania*. For example, reticulate or tuberculate seed-coats, size of the seeds, fruits being non-septate or septate, shape of trichomoses, and shape of leaflet and blade are primary differences between the two genera which are very consistent. Other evidence against the combination of *Hilliella* and *Yinshania* in one genus, such as chromosome numbers and ploidy levels (Goldblatt & Johnson, 2000), different ecological adaptations and geographical distribution, has been fully discussed in the preceding sections. All of these differences, similarities and variations may indicate that *Hilliella* and *Yinshania* came from a common ancestor and gradually differentiated into a pair of sister taxa. Therefore, placing them into separate genera is more in keeping with their phylogenetic relationship in Brassicaceae.

Nowadays, molecular phylogenetic approaches provide powerful tools for understanding the relationships within taxa. As previously mentioned, Koch & Al-Shehbaz (2000) have worked on *Hilliella* and *Yinshania* with molecular tools. Despite their contrary interpretation, their results do not support the single genus delimitation, but show that *Hilliella* and *Yinshania* form two natural groups.

One of the most important standards which taxonomists use to evaluate a classification system is that a scientific taxonomic system should possess a high predicative value. The better a system is, the higher predicative value it has. I expect that the more work is carried out on chemistry, chromosome number and molecular analysis of *Hilliella/Yinshania*, the more evidence would be found

supporting the delimitation of the two genera.

Finally, I would like to mention the floral characters. Zhou et al. (2001) state that "The most reliable determination of genera can be achieved when the material has both fruit and flowers and when both keys are successfully used to reach the same genus". However, in *Hilliella* and *Yinshania* the flowers are very similar, and the fruit characters, seed characters and vegetative characters such as leaf shape, hair shape and so on are very different. In such cases, fruit, seed and vegetative characters should be used to delimit the taxa. Here I would like to quote from the famous work, Principles of Angiosperm Taxonomy (Davis & Heywood, 1963) to express my opinion that "there is no reason why vegetative characters should not be as good as floral ones for the delimitation of taxa. Which is used should depend on character correlation and discontinuity of variation." They state further that " Indeed, a family which shows marked diversity of elaboration in flower structure seldom shows it in its fruits or seeds—and vice versa (cf. Scrophulariaceae, Labiatae and Orchidaceae on one hand, Cruciferae, Umbelliferae and Gramineae on the other)". The Brassicaceae (Cruciferae) is obviously a very natural family with highly conserved floral characters, so it is necessary to find other characters for natural delimitation of taxa. In practice, using fruit, seed and vegetative characters, *Hilliella* and *Yinshania* are very readily distinguished. According to Davis & Heywood (1963), "We should always bear in mind that the most important "function" of the genus is to bring together species, preferably in a natural manner". Davis and Heywood also quoted Rollins (1953) who said that "It is my contention that a genus is made up of a group of closely related species. In determining the nature and even the limits of a given genus, interest should center upon the relationship of the species. When attempting to place a species in a given genus, the primary question should be, is it related to the undoubted species of that genus?" Finally Davis & Heywood (1963) state that "The idea that a genus should always be readily definable on a few technical floral characters no longer holds the field as the prime generic criterion; the overriding consideration is whether it is naturally delimited".

Acknowledgements: This study is based on specimens from the following herbaria: A, ANUB, B, BJTC, BM, CDBI, E, FNU, HAST, HHBG, HIB, HIMC, HNNU, HZU, IBSC, K, KUN, LBG, LE, MO, NAS, NY, P, PE, SG, SHCT, SHM, SM, SRMC, SZ, TAI, TI, TNS, US, W, WU, WUK, ZJFC, ZJMA, ZM. I wish to thank all the curators and directors of these herbaria who made it possible to study the materials related to this study, and to thank Dr. I. A. Al-Shehbaz for allowing me to look at some of the specimens he borrowed in the meantime. I am grateful to Professors WANG Wen-Tsai, LI Zhen-Yu, ZHENG Zhao-Zong, FU Cheng-Xin, DING Bing-Yang and WANG Yun for their support of this work and helpful comments of my manuscript; and to Dr. WANG Xiao-Quan and CHEN Yong for assistance with molecular analysis. Finally, I wish to express cordial acknowledgements to my friends at the University of Auckland, New Zealand where I had visited in the Laboratory of Plant Genetics and Systematics: to Professor Brian Murray and Dr. Paul Datson for assistance with cytogenetic analysis; to Dr. Peter de Lange for helpful taxonomic comments, and especially to Dr. Joshua Salter for various kinds of assistance on the manuscript.

I am also very grateful to Dr. WANG Yun (in Dunedin, N. Z.) and Dr. Joshua Salter for revising my English. Line drawings are by the author.

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泡果荠属和阴山荠属(十字花科)的分属界限及两属的分类校订

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摘要 泡果荠属 *Hilliella* 和阴山荠属 *Yinshania* 是十字花科中国特有的两小群植物,但是,它们的分属界定却一直颇有争议。本文结合前人的研究结果重新对这两群植物做了研究,从而进一步确认这两群植物应该界定为两个属,即泡果荠属和阴山荠属。文中比较了两属间重要的性状特征,并指出它们的主要区别在于:泡果荠属果实无假隔膜,种子较大,表面具小瘤状突起,染色体倍性为六倍体(2n = 6x = 42);而阴山荠属果实有假隔膜,种子较小,表面具网纹,染色体倍性为二倍体(2n = 2x = 12)。两属其他方面如叶形态、叶表皮结构、被毛类型、地理分布和生境等方面也都存在着一系列区别。这些性状特征的明显不同,作为界定两属的界限不仅足够而且清楚。本文对界定两属的观点和界定一属的看法做了详细的分析讨论,对两属的属下分类单位也作了校订。长柱泡果荠 *H. longistyla* Y. H. Zhang、黎川泡果荠 *H. lichuanensis* Y. H. Zhang 和广东泡果荠 *H. guangdongensis* Y. H. Zhang 降级作变种处理。泡果荠属包括有 11 种和 4 个变种。阴山荠属属下仍为两个组:sect. *Yinshania* 和 sect. *Microcarpa* Y. H. Zhang,包括 8 个种和 2 个变种;做出 1 新组合: *Y. acutangula* (O. E. Schulz) Y. H. Zhang var. *gobica* (Z. X. An) Y. H. Zhang。文中对两属的属下检索表和分种描述也做了进一步的修订。

关键词 十字花科; 泡果荠属; 阴山荠属; 分类