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Notes on *Carex* (Cyperaceae) from China (IV): the identity and revision of sect. *Infossae*

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Abstract: *Carex* sect. *Infossae* S. W. Su was recently described from Anhui and Jiangsu provinces of East China，containing two species with one variety： *C. infossa* var. *infossa*，*C. infossa* var. *extensa* and *C. minuticulmis*. According to the sectional description，fifteen additional species and two varieties should be placed in this section. Based upon literature survey，specimen examination，field work，and SEM observation of perigynia and achenes，a concise table of different treatments between *Florae Reipublicae Popularis Sinicae* and *Flora of China* was provided，as well as the morphological characters distinguishing these taxa and micromorphology of perigynia and achenes for the selected taxa were compared. Among the diagnostic characters，arrangement of spikes and perigynium indumentum are inseparable from each other，and two species in sect. *Infossae* are consequently recognized in the present paper. *Carex elmeri*，*C. granifera*，*C. minuticulmis*，*C. shanghaiensis*，*C. blinii* subsp. *shanghaiensis*，*C. sublateralis*，*C. taihokuensis* and *C. tatsutakensis* were synonymized to *C. blinii*. *Carex canaliculata*，*C. changmuensis*，*C. distantiflora*，*C. infossa*，*C. infossa* var. *extensa*，*C. lateralis*，*C. loheri*，*C. longerostrata* var. *exaristata*，*C. longerostrata* var. *hoi*，*C. lyi*，*C. macrandrolepis*，*C. sharyotensis* were reduced as synonyms to *C. oxyphylla*.

Key words： *Carex* sect. *Infossae*，scanning electron microscopy，morphological character，new synonym，China
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中国薹草属（莎草科）研究随记（IV）：隐匿薹草组的分类修订

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摘 要：隐匿薹草组(*Carex* sect. *Infossae*)为最近建立的薹草属(*Carex*)的组，当时报导分布于我国安徽和江苏，有 2 种和 1 变种，即隐匿薹草(*C. infossa*)、显穗薹草(变种) (*C. infossa* var. *extensa*)和矮秆薹草(*C. minuticulmis*)。根据描述，另有 15 种和 2 变种应归属本组，这些分类群具有较为一致的特征：果囊椭圆球状卵球形或卵球形，通常疏被短毛或近无毛，先端渐狭成中等长的喙，喙口具 2 小齿；瘦果卵球形，先端钝或微凹。通过文献考证、标本查阅、野外采集，并结合果囊和瘦果的扫描电镜观察，对隐匿薹草组所涉及的种（含种下类群）进行了分类修订。该组仅有 2 种：百里薹草（*C. blinii*）和尖叶薹草（*C. oxyphylla*）。将 *Carex elmeri*、*C. granifera*、

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矮秆薹草（*C. minuticulmis*）、上海薹草（*C. shanghaiensis C. blinii* subsp. *shanghaiensis*）、*C. sublateralis*、*C. taihokuensis* 和锐果薹草(*C. tatsutakensis*)并入百里薹草；将沟囊薹草(*C. canaliculata*)、樟木薹草(*C. changmuensis*)、*C. distantiflora*、隐匿薹草(*C. infossa*)、显穗薹草(*C. infossa* var. *extensa*)、*C. lateralis*、*C. loheri*、无芒长嘴薹草(*C. longerostrata* var. *exaristata*)、城湾薹草(*C. longerostrata* var. *hoi*)、*C. lyi*、和平菱果薹草(*C. macrandrolepis*)和 *C. sharyotensis* 并入尖叶薹草。

关键词：隐匿薹草组，扫描电镜，形态学性状，新异名，中国

Su (2009) established *Carex* sect. *Infossae* S. W. Su，designating *C. infossa* Z. P. Wang as the type. The section as originally described and contained two species and one variety: *C. infossa* Z. P. Wang，*C. infossa* var. *extensa* S. W. Su，and *C. minuticulmis* S. W. Su & S. M. Xu (Su，1996，2009; Su & Xu，1988). According to Su's delimitation，the section is morphologically similar to sect. *Radicales* (Kük.) Nelmes and sect. *Clandestinae* G. Don. It differs from the former in having spikes unisexual. It differs from the latter in having involucral bracts leaf-like，longer than spikes，shortly sheathed; achenes emarginate at apex; and styles thickened at base but caducous (Su，2009).

China is incredibly rich in *Carex*，with more than 500 species (Dai et al，2000，2010). Because of scattered preservation of the literature and specimens，the taxonomic treatment of *Carex* in China was not in a satisfactory status，and extensive examination of specimens and field collection of new material are needed. Morphological characters of perigynia and achenes under a 10× hand lens can be used in species identification and traditional taxonomy of *Carex* (Ohwi，1936; Nelmes，1951; Dai et al，2000，2010; Jin & Zheng，2013). Micromorpholoy of perigynia and achenes under SEM provided evidences for traditional taxonomy in both interspecific and intraspecific levels，as well as sectional delimitation (Toivonem & Timonen，1976; Menapace & Wujek，1987; Waterway，1990; Jin & Zheng，2010，Jin et al, 2013).

Based on specimen examination，we found several taxa with achenes similar to those of sect. *Infossae*，most distributed in China. They were: *Carex blinii* H. Lév. & Vaniot，*C. canaliculata* P. C. Li，*C. changmuensis* Tang & F. T. Wang ex Y. C. Yang，*C. distantiflora* Nakai，*C. elmeri* Kük.，*C. granifera* Dunn，*C. lateralis* Kük.，*C. loheri* C. B. Clarke，*C. longirostrata* C. A. Meyer var. *exaristata* X. F. Jin & C. Z. Zheng，*C. longirostrata* var. *hoi* Chü ex S. Yun Liang，*C. lyi* H. Lév.，*C. macrandrolepsis* H. Lév.，*C. oxyphylla* Franch.，*C. shanghaiensis* S. X. Qian & Y. Q. Liu，*C. sharyotensis* Hayata，*C. sublateralis* T. Koyama，*C. taihokuensis* Hayata and *C. tatsutakensis* Hayata (Franchet，1898; Clarke，1904; Léveillé，1906，1907，1908; Dunn，1908; Kükenthal，1909，1910; Nakai，1914; Hayata，1916，1921; Koyama，1956; Yang，1987; Li，1990; Liang，1998; Liu and Qian，1999; Jin et al，2004). All these above-mentioned taxa have the consistent characters of perigynia and achenes: perigynia ellipsoid-obovoid to ovoid，or nearly globose，obtusely trigonous，sparsely pubescent or nearly glabrous，apex gradually contracted into a beak; beaks mid-sized in length; orifice 2-lobed with minute teeth; achenes frequently ovoid，trigonous，excavate or obtuse at apex，stipitate at base. According to the shapes of perigynium and achene，these species and varieties should be placed in sect. *Infossae*.

Although taxonomic revisions of the above-mentioned taxa were published in *Flora Reipublicae Popularis Sinicae* (Vol. 12) and *Flora of China* (Vol. 23)，species treatment or their sectional placement were problematic (Dai et al，2000，2010). Important differences between the species treatments of *Flora Reipublicae Popularis Sinicae* (Vol. 12) and *Flora of China* (Vol. 23) are shown in Table 1.

The present study of the taxonomic status of the species in sect. *Infossae* is based on: (i) carefully checking and critical examination of all available type specimens; (ii) observations of morphological variation within and among populations of the related species/variety; (iii) observations of variation in perigynium indumentum; and (iv) observations of achene shape and sexine ornamentation of the selected taxa.

1　Materials and Methods

1.1 Examination of type specimens

Type specimens of these taxa were examined and

Table 1 Different treatments of the species in *Carex* sect. *Infossae* between *Flora Reipublicae Popularis Sinicae* and *Flora of China*

Flora Reipublicae Popularis Sinicae (Dai et al，2000)	*Flora of China* (Dai et al，2010)
sect. *Clandestinae* G. Don	sect. *Clandestinae* G. Don
Carex infossa C. P. Wang	*C. infossa* C. P. Wang
C. infossa var. *extensa* S. W. Su	*C. infossa* var. *extensa* S. W. Su
	C. minuticulmis S. W. Su & S. M. Xu
sect. *Rhomboidales* Kükenthal (1909: 622)	sect. *Rhomboidales* Kük.
C. oxyphylla Franch.	*C. oxyphylla* Franch.
C. blinii H. Lév. & Vaniot (doubtful)	*C. blinii* H. Lév. & Vaniot
	C. longirostrata var. exaristata X. F. Jin & C. Z. Zheng
	C. longirostrata var. *hoi* Chü ex S. Yun Liang
	C. macrandrolepsis H. Lév. & Vaniot
	syn. *C. sharyotensis* Hayata
	C. blinii ssp. *shanghaiensis* (S. X. Qian & Y. Q. Liu) S. Yun Liang & T. Koyama
	C. tatsutakensis Hayata
	syn. *C. taihokuensis* Hayata
sect. *Careyanae* Tuckerman ex Kükenthal (1909: 679)	sect. *Careyanae* Tuckerm. ex Kük.
C. longirostrata C. A. Mey. var. *hoi* Chü ex S. Yun Liang	*C. canaliculata* P. C. Li
C. macrandrolepsis H. Lév. & Vaniot	*C. changmuensis* Tang & F. T. Wang ex Y. C. Yang
syn. *C. sharyotensis* Hayata	
C. shanghaiensis S. X. Qian & Y. Q. Liu	
C. tatsutakensis Hayata	
syn. *C. taihokuensis* Hayata	
C. canaliculata P. C. Li	
species not treated	species not treated
C. changmuensis Tang & F. T. Wang ex Y. C. Yang	*C. granifera* Dunn
C. granifera Dunn	*C. lyi* H. Lév. & Vaniot
C. lyi H. Lév. & Vaniot	*C. sublateralis* T. Koyama
C. minuticulmis S. W. Su & S. M. Xu	
C. sublateralis T. Koyama	

carefully checked. Although different taxonomists placed these taxa in different sections，the above-mentioned taxa are very similar to each another. Our observations of type specimens focused on all diagnostic characters，such as bract sheath，arrangement of spikes，and perigynium indumentum (Table 2).

1.2 Observations on morphological characters

To observe morphological character variation within and among populations both in *Carex blinii* and *C. infossa*，collections from five different populations were checked as well. Among these populations，specimens of four populations were collected by the authors and those of the population，Chuzhou of Anhui，were checked from the herbarium of ACM and determined as *C. infossa*. The collections from the other four populations were all determined as *C. blinii*. Twenty-eight sheets representing as many individuals were obtained，and six individuals were collected from the population at Chuzhou. Of the others，five individuals were from the population at Hangzhou，five from Libo，and six from each of Lin'an and Yueqing (Table 3).

1.3 Scanning electron microscopy (SEM) of perigynium indumentum and achene for selected taxa

Mature perigynia were gathered from 15 specimens housed in ACM，HTC，HZU，KYO，N，P，PE and TI，representing eight species and three varieties (Appendix). Perigynia were submerged in 50% ethanol to clean for 2 h，then air dried. For SEM，cleaned perigynia were mounted on stubs using doubled-sided adhesive tape and coated with gold.

Twelve achene samples representing seven species and two varieties were gathered from specimens deposited in ACM，HTC，KYO，N and TI (Appendix). Mature achenes were initially soaked in a solution of concentrated sulfuric acid and acetic anhydride (volume ratio=1:9) for 18 h，then rinsed in acetic acid for 10 min and water for 5 min，and placed in a bath-type ultrasonic cleaner for 30 min with 70% ethanol to remove the cuticle and outer periclinal wall of epidermis (Oda et al，2003; Zhang，2006). After air drying，the achenes were mounted on stubs using double-sided adhesive tape，and directly

Table 2　Observation on type specimens of the species in *Carex* sect. *Infossae*

Species name	Specimen	Bract sheath	Arrangement of spike	Perigynium indumentums density
Carex blinii	J. Esquirol 343 (lectotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (1)
C. canaliculata	Qinghai-Xizang Exped. 6584 (holotype)	Sheathed，0.5-1.5 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
	Qinghai-Xizang Exped. 6584 (isotype)	Sheathed，0.6-0.9 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
	Qinghai-Xizang Exped. 6584 (isotype)	Sheathed，0.7-1.2 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
	Qinghai-Xizang Exped. 6584 (isotype)	Sheathed，0.5-1.2 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
C. changmuensis	Y. T. Chang & K. Y. Lang 3227 (holotype)	Short-sheathed，0.3-0.5 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
C. distantiflora	T. Nakai 1332 (lectotype)	Sheathed，1-2.5 cm long	Remote	Sparsely pubescent (1)
	T. Nakai 941 (syntype)	Sheathed，0.7-3 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
	Y. Tsujikuma s. n. (syntype)	Short-sheathed，0.4-0.8 cm long	Remote	Sparsely pubescent (1)
C. elmeri	A. D. E. Elmer 8444 (holotype)	Short-sheathed，ca. 0.3 cm long	Crowded，nearly capitate	Sparsely pubescent (1)
C. granifera	HK Herb. 3655 (holotype)	Almost not-sheathed	Crowded，nearly capitate	Nearly glabrous (0)
C. infossa	C. P. Wang 76 (holotype)	Short-sheathed，0.3-0.7 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (2)
	C. P. Wang 76 (isotype)	Short-sheathed，0.4-1 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (2)
C. infossa var. *extensa*	S. W. Su 82005 (isotype)	Sheathed，0.7-1.5 cm long	Remote	Sparsely pubescent (1)
C. lateralis	anonymous 11061 (holotype)	Short-sheathed，0.4-0.7 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (2)
C. loheri	A. Loher 701 (holotype)	Sheathed，0.5-2 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (2)
C. longirostrata var. *exaristata*	Q. C. Chen & J. H. Zhou 1879 (holotype)	Sheathed，1-2 cm long	Remote	Nearly glabrous (0)
	Q. C. Chen & J. H. Zhou 1879 (isotype)	Sheathed，ca. 1.5 cm long	Remote	Nearly glabrous (0)
C. longirostrata var. *hoi*	Y. Y. Ho 943 (holotype)	Short-sheathed，0.5-0.8 cm long	Remote	Sparsely pubescent (1)
C. lyi	J. Cavalerie 2329 (holotype)	Short-sheathed to sheathed，0.3-2 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
	J. Cavalerie 2329 (isotype)	Sheathed，0.6-1.5 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
C. macrandrolepsis	U. Faurie 2285 (isotype)	Sheathed，0.5-1.5 cm long	Remote	Sparsely pubescent (1)
C. minuticulmis	S. W. Su 2477 (holotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (3)
C. oxyphylla	Delavey 2524 (holotype)	Short-sheathed to sheathed，0.3-1.8 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
	Delavey 2524 (isotype)	Short-sheathed to sheathed，0.4-1.5 cm long	Terminal two crowded，lowers remote	Sparsely pubescent (1)
C. shanghaiensis	Y. Q. Liu & S. X. Qian 63 (holotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (3)
C. sharyotensis	B. Hayata s. n. (holotype)	Short-sheathed to sheathed，0.5-1.3 cm long	Remote	Nearly glabrous (0)
C. sublateralis	K. Kimura s. n. (holotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (3)
C. taihokuensis	U. Faurie s. n. (holotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (1)
	U. Faurie s. n. (isotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (1)
C. tatsutakensis	W. R. Price 797 (holotype)	Almost not-sheathed	Crowded，nearly capitate	Sparsely pubescent (2)

Note: the numbers in brackets denote the gradual status, with 0 expressing nearly glabrous, and 1, 2, 3 expressing gradual status.

Table 3 Observation on individuals/specimens from different populations

Population name	Specimen	Bract sheath	Arrangement of spike	Perigynium indumentum
Chuzhou of Anhui, China	S. W. Su 81065 [2]*	Sheathed, 0.6-1.5 cm long	Terminal two crowde, lowers remote/ or remote	Sparsely pubescent (1)**
Carex infossa	Anonymous s. n. [4]	Sheathed, 0.5-2 cm long	Terminal two crowde, lowers remote/ or remote	Sparsely pubescent (2)
Hangzhou of Zhejiang, China	H. Wang & X. F. Jin 1444 [2]	Almost not-sheathed	Crowded, nearly capitate	Sparsely pubescent (2)
Carex blinii	H. Wang & X. F. Jin 1446 [3]	Almost not-sheathed	Crowded, nearly capitate	Sparsely pubescent (2)
Libo of Guizhou, China	X. F. Jin et al 2388 [2]	Almost not-sheathed	Crowded, nearly capitate	Sparsely pubescent (1)
Carex blinii	X. F. Jin et al 2390 [3]	Almost not-sheathed	Crowded, nearly capitate	Sparsely pubescent (1)
Lin'an of Zhejiang, China	X. F. Jin & Y. Y. Zhou 3050 [3]	Almost not-sheathed	Crowded, nearly capitate	Sparsely pubescent (2)
Carex blinii	X. F. Jin & Y. Y. Zhou 3051 [3]	Almost not-sheathed	Crowded, nearly capitate	Sparsely pubescent (2)
Yueqing of Zhejiang, China	X. F. Jin & P. J Cao 1529 [3]	Almost not-sheathed	Crowded, nearly capitate	Nearly glabrous (0)
Carex blinii	X. F. Jin & P. J Cao 1533 [3]	Almost not-sheathed	Crowded, nearly capitate	Nearly glabrous (0)

Note: * the numbers in square brackets denote observed individuals or specimens; ** the numbers in brackets denote the gradualstatus, with 0 expressing nearly glabrous, and 1, 2, 3 expressing gradual status.

coated with a layer of gold.

The coated perigynia and achenes were observed and photographed under a Philips XL-30E scanning electron microscope.

2 Results and Analysis

2.1 Morphological variations on type specimens

Based on the observation on type specimens (Fig. 1, 2), sheaths of involucral bracts, arrangement of spikes and perigynium indumentum are shown in Table 2. The bract sheaths of these taxa indicate: (I) almost sheathless, e.g. *Carex blinii*, *C. granifera*, *C. minuticulmis*, *C. shanghaiensis*, *C. sublateralis*, *C. taihokuensis* and *C. tatsutakensis*; (II) short-sheathed, e.g. *C. changmuensis*, *C. elmeri*, *C. lateralis*, *C. infossa* and *C. longirostrata* var. *hoi*; (III) sheathed, e.g. *C. canaliculata*, *C. infossa* var. *extensa*, *C. loheri* and *C. longirostrata* var. *exaristata*. The bract sheaths of *C. distantiflora* shows short-sheathed or sheathed in different type specimens, while those of *C. lyi*, *C. oxyphylla* and *C. sharyotensis* show short-sheathed to sheathed in the same specimens.

Spikes of the above-mentioned taxa arranged as the following patterns: (I) all spikes crowded, nearly capitate, e.g. *Carex blinii*, *C. elmeri*, *C. granifera*, *C. minuticulmis*, *C. shanghaiensis*, *C. sublateralis*, *C. taihokuensis* and *C. tatsutakensis*; (II) terminal two spikes crowded, lowers remote, e.g. *C. canaliculata*, *C. changmuensis*, *C. infossa*, *C. lateralis*, *C. loheri*, *C. lyi* and *C. oxyphylla*; (III) all spikes remote, e.g. *C. infossa* var. *extensa*, *C. longirostrata* var. *exaristata*, *C. longirostrata* var *hoi*, *C. macrandrolepsis* and *C. sharyotensis*. Among three syntypes of *C. distantiflora*, one specimen (T. Nakai 941) shows the distal two spikes arranged crowded, proximal spikes remote. The other two specimens show all spikes remote (Table 2).

Most of the taxa have sparsely pubescent perigynia, but the indumentum ranges in density from nearly glabrous, such as *Carex granifera*, *C. longirostrata* var. *exaristata* and *C. sharyotensis*, to more densely pubescent in *C. minuticulmis*, *C. sublateralis* and *C. shanghaiensis* (Table 2).

Noticeably, the description of the leaves of *Carex minuticulmis* is pubescent in *Flora of China* (Dai et al, 2010), whereas those in the protologue are glabrous (Su & Xu, 1988). The examination of the type specimen of *C. minuticulmis* indicates all leaves are glabrous on both surfaces, which is consistent to the description in the protologue.

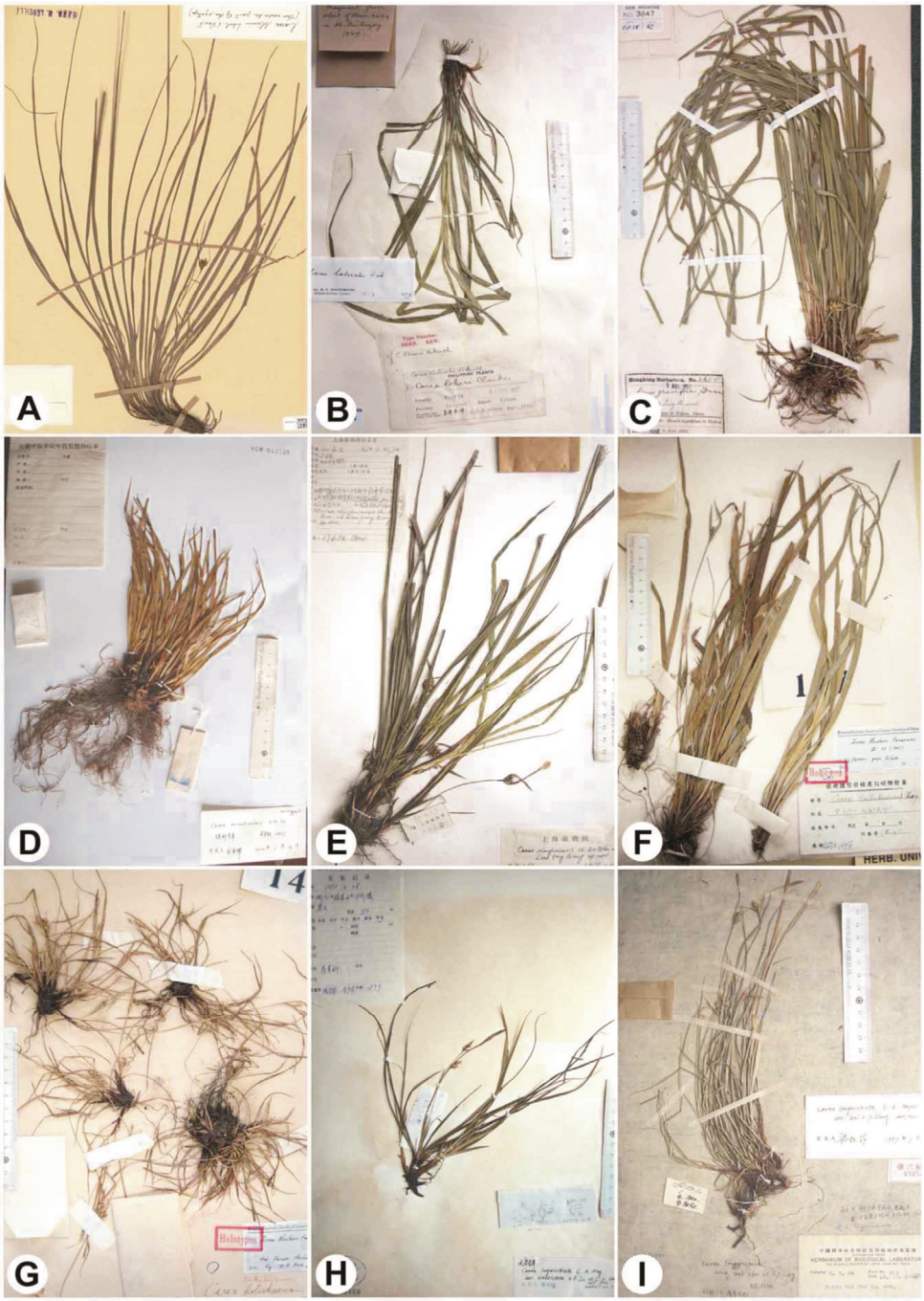

Fig. 1　Types of nine taxa in *Carex* sect. *Infossae*　**A**. *Carex blinii* (lectotype，P)；**B**. *C. elmeri* (holotype，K)；**C**. *C. granifera* (holotype，K)；**D**. *C. minuticulmis* (holotype，AHU tranferred to ACM)；**E**. *C. shanghaiensis* (holotype，PE)；**F**. *C. taihokuensis* (holotype，TI)；**G**. *C. tastutakensis* (holotype，TI)；**H**. *C. longirostrata* var. *exaristata* (holotype，HZU)；**I**. *C. longirostrata* var. *hoi* (holotype，PE).

2.2 Morphological variation within and among populations in *Carex blinii* and *C. infossa*

Bract sheath，arrangement of spikes and perigynium indumentum were observed from different populations and shown in Table 3. The bracts of the individuals of *Carex blinii* from the populations Hangzhou，Libo，Lin'an and Yueqing are inconspcuously sheathed，almost sheathless. The spikes of the individuals in these populations are crowded，nearly capitate. The perigynium indumentum of the population Yueqing is nearly glabrous，and those of Hangzhou，Libo and Lin'an are sparsely pubescent but with different gradual status of density.　The bracts of the

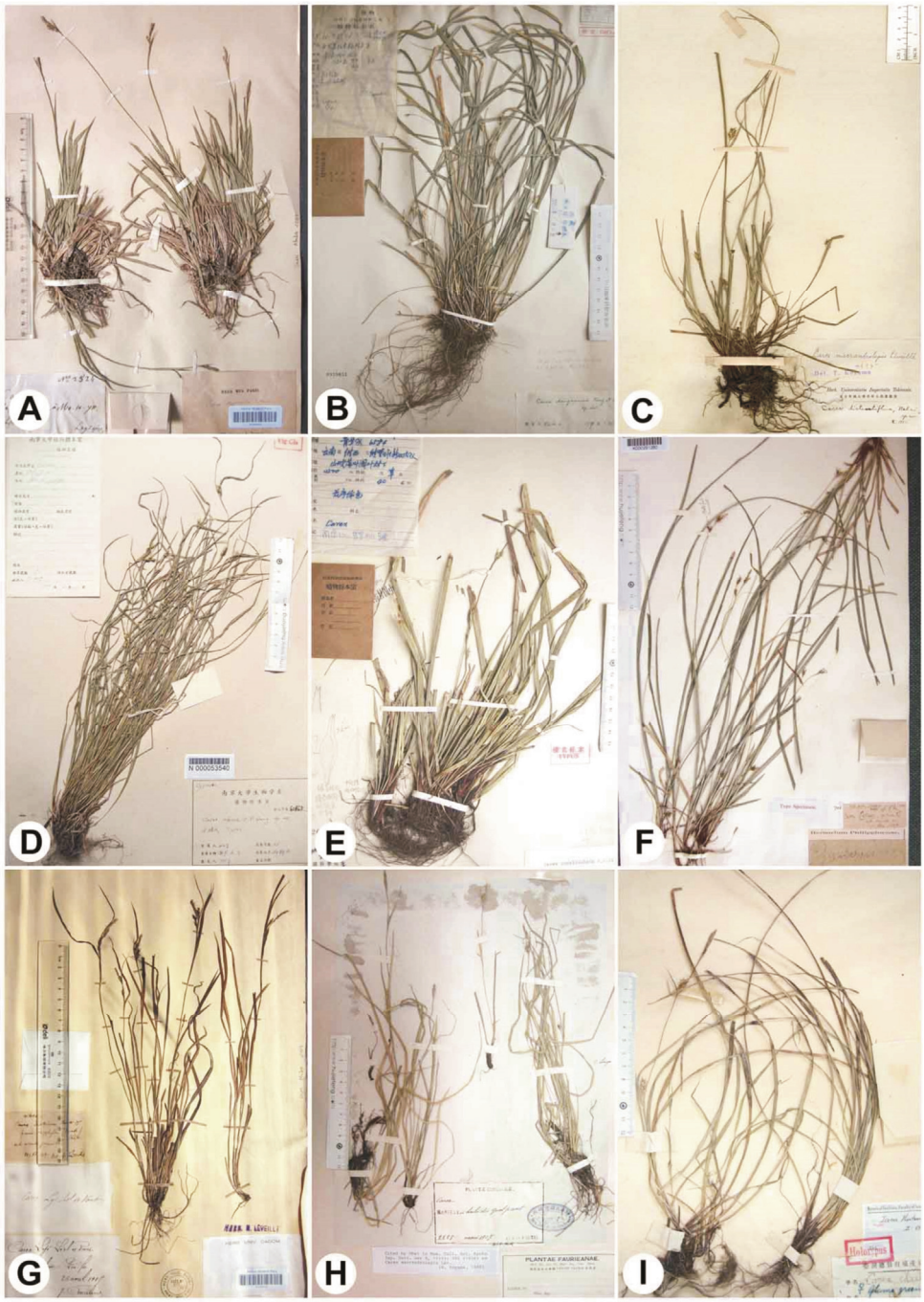

Fig. 2 Types of nine species in *Carex* sect. *Infossae* **A**. *Carex oxyphylla* (holotype，P)； **B**. *C. changmuensis* (holotype，PE)； **C**. *C. distantiflora* (lectotype，TI)； **D**. *C. infossa* (holotype，N)； **E**. *C. canaliculata* (holotype，PE)； **F**. *C. loheri* (holotype，K)； **G**. *C. lyi* (holotype，P)； **H**. *C. macrandrolepsis* (isotype，KYO)； **I**. *C. sharyotensis* (holotype，TI).

individuals of *Carex infossa* from the population Chuzhou are sheathed. The lower spikes are remote，but terminal two spikes sometimes crowded. The perigynium indumentum is also sparsely pubescent with different gradual status of density. Two sheets of the specimens (S. W. Su 81065) have the perigynia with very sparsely pubescence，but four sheets (anonymous s. n.) are more densely pubescent.

2.3 Perigynium indumentum under SEM

The perigynium indumentum of eight species and three varieties in *Carex* sect. *Infossae* were observed using SEM. All samples show some degree of pubescence， and perigynia of *C. longirostrata* var. *exaristata*，*C. sharyotensis*

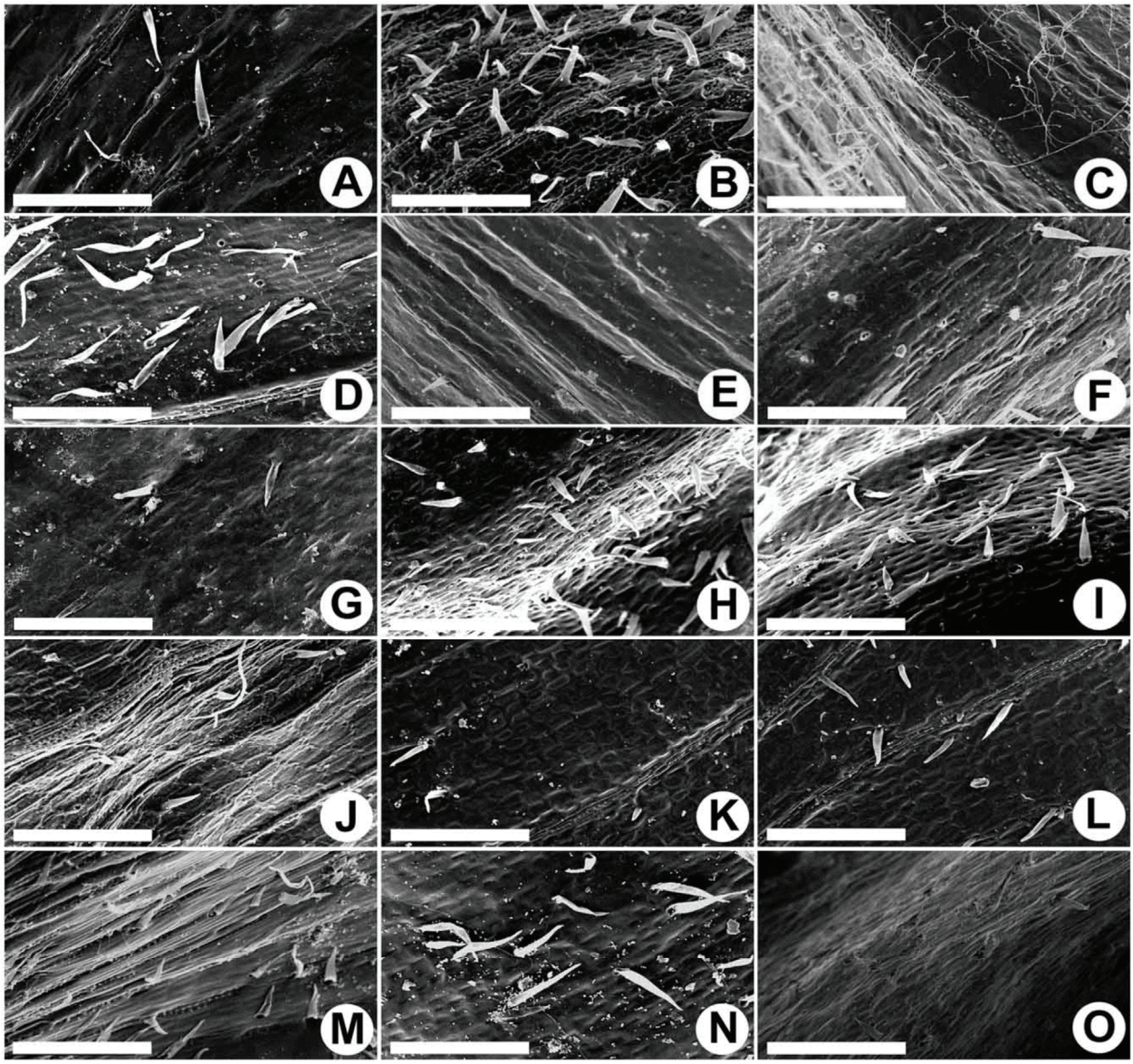

Fig. 3　Perigynium indumentum of the taxa in *Carex* sect. *Infossae* under SEM　**A**. *Carex blinii* (Sample 1)；**B**. *C. blinii* (Sample 2)；**C**. *C. blinii* (sample 3)；**D**. *C. minuticulmis*；**E**. *C. taihokuensis*；**F**. *C. tatsutakensis*；**G**. *C. oxyphylla*；**H**. *C. infossa* var. *extensa*；**I**. *C. infossa*；**J**. *C. infossa*；**K**. *C. longirostrata* var. *exaristata*；**L**. *C. longirostrata* var. *hoi*；**M**. *C. macrandrolepsis* (sample 1)；**N**. *C. macrandrolepsis* (sample 2)；**O**. *C. sharyotensis*. Scale bar: all=200 μm.

and *C. taihokuensis* are nearly glabrous. The samples from different localities/populations for the same species show sparse pubescence to varying degrees (Fig. 3)，which is consistent with the observation on types or populations.

2.4 Achene shape and sexine ornamentation under SEM

The achene shape of the taxa in *Carex* sect. *Infossae* isovoid，rarely obovoid or broadly ovoid，trigonous; beaks absent，excavate rarely obtuse at apex; sides slightly concave. The achene shapes of the three samples of *C. infossa* range from obovoid in Jiangsu to ovoid in Anhui and Zhejiang，(Fig. 4). The periclinal cells of all samples are straight，with silica bodies generally one per cell，occasionally two or three (Fig. 4).

3　Taxonmic Treatment

Based on morphological observations on the type specimens and population collections，the diagnostic

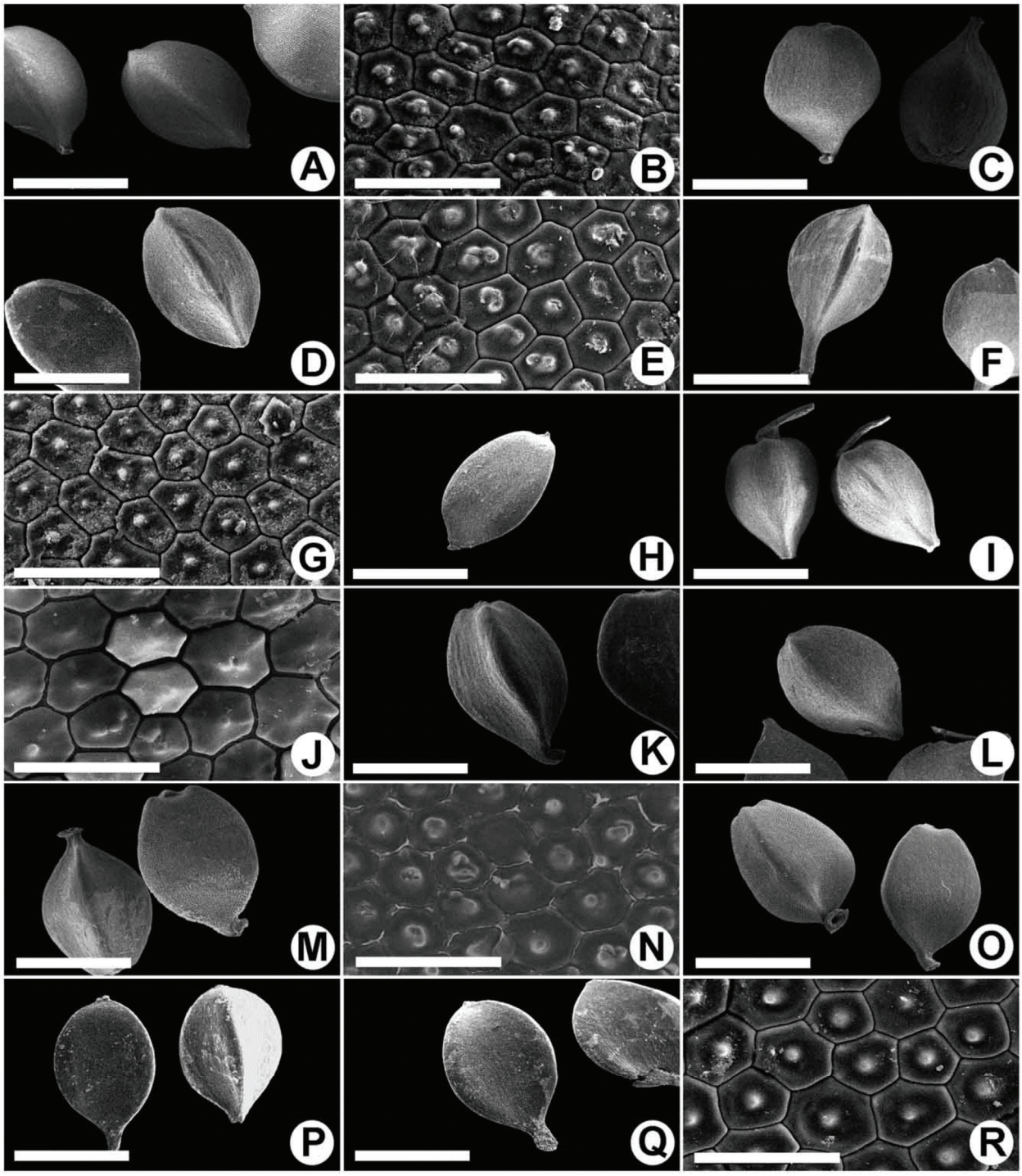

Fig. 4 Achene micromorphology of the taxa in *Carex* sect. *Infossae* under SEM **A**，**C**，**D**，**F**，**H**，**I**，**K**–**M**，**O**–**Q**. Achene shape；**B**，**E**，**G**，**J**，**N**，**R**. Sexine ornamentation. **A**，**B**. *Carex blinii*； **C**. *C. minuticulmis*； **D**，**E**. *C. taihokuensis*； **F**，**G**. *C. tatsutakensis* (Sample 1)； **H**. *C. tatsutakensis* (Sample 2)； **I**，**J**. *C. infossa* (sample 1)； **K**. *C. infossa* (Sample 2)； **L**. *C. infossa* (Sample 3)； **M**，**N**. *C. longirostrata* var. *exaristata*； **O**. *C. longirostrata* var. *hoi*； **P**. *C. macrandrolepsis* (Sample 1)； **Q**，**R**. *C. macrandrolepsis* (Sample 2). Scale bars: **A**，**C**，**D**，**F**，**H**，**I**，**K**–**M**，**O**–**Q**=2 mm； **B**，**E**，**G**，**J**，**N**，**R**=100 μm.

characters among these taxa are as follows: bract sheath，arrangement of spikes，and perigynium indumentums. These characters were carefully checked and evaluated. We here treat the taxa in *Carex* sect. *Infossa* as two distinct species，and use two prior names *C. blinii* H. Lév. & Vaniot and *C. oxyphylla* Franch.，respectively.

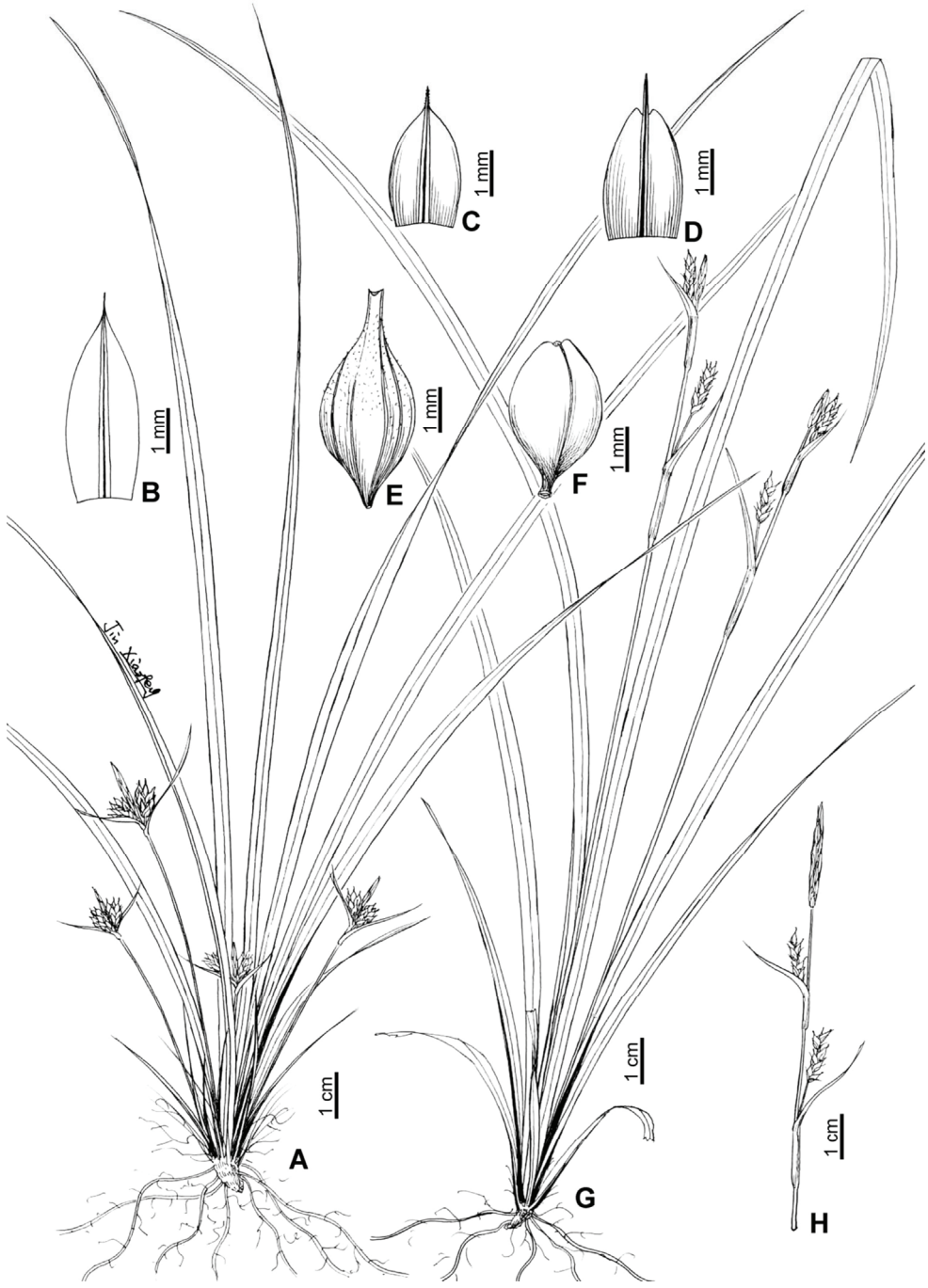

Fig. 5　*Carex blinii* (A–F) and *C. oxyphylla* (G，H)　**A**，**G**. Habit；　**B**. Staminate scale；　**C**，**D**. Pistillate scale；　**E**. Perigynium；　**F**. Achene；　**H**. Inflorescence. (**A**–**F** from　X. F. Jin & al. 2390，HTC；　**G** from　H. Wang & X. F. Jin 1445，HTC；　**H** from anonymous s. n.，ACM).

Carex sect. ***Infossae*** S. W. Su，J. Anhui Agric. Univ. 36: 562. 2009. TYPE: *C. infossa* Z. P. Wang (=*C. oxyphylla* Franch.).

Perennial herbs. Culms central or lateral，trigonous. Leaves longer than culms，or almost equal in length. Involucral bract leaf-like or shortly leaf-like，shorter than inflorescence，almost sheathless or short-sheathed to conspicuously sheathed. Inflorescence paniculate，spikes 2–5; spikes crowded，or distal two spikes crowded，or all remote; terminal spike staminate; lateral spikes pistillate. Perigynia ellipsoid-obovoid，obovoid，ovoid or nearly globose (excluding beaks)，obtusely trigonous，distinctly or

Key to the species of *Carex* sect. *Infossae*.

1a. Culms lateral，<15 cm; involucral bracts almost not-sheathed; spikes crowded ……***Carex blinii*** H. Lév. & Vaniot

1b. Culms central，rarely lateral，(10–)20–40 cm tall; involucral bracts short-sheathed to conspicuously sheathed; spikes remote，or distal two spikes crowded，proximal spikes remote ……***C. oxyphylla*** Franch.

inconspicuously veined，sparsely pubescent or nearly glabrous，apex gradually contracted into a beak; orifice 2-lobed with minute teeth. Stigmas 3; style thickened at base. Achenes tightly enveloped，ovoid，rarely obovoid or broadly ovoid，trigonous，sides slightly concave，excavate or obtuse at apex，erect or curved，stipitate at base.

This section is somewhat morphologically similar to *Carex* sect. *Clandestinae* G. Don，but differs in having involucral bracts leaf-like，longer than spikes，shortly sheathed; achenes emarginate at apex; styles thickened at base but caduceus.

Two species are recognized，and the key to these two species is as following.

3.1 *Carex blinii* H. Lév. & Vaniot，Bull. Soc. Bot. France 53: 316. 1906. TYPE: China，Kwei-tschou (Guizhou): Pintong (Pingtang)，no date，J. Esquirol 343 (lectotype，P!). Fig 5: A-F

C. elmeri Kük.，Repert. Spec. Nov. Regni Veg. 8: 326. 1910. TYPE: Philippines，Luzon Isl.，Baguio，23 Dec 1907，A. D. E. Elmer 8444 (holotype，K!; isotype，E!).

C. granifera Dunn，J. Linn. Soc.，Bot. 38: 372. 1908. TYPE: China，Fokien (Fujian)，Tap Long Ho Wood，no date，HK Herb. 3655 (holotype，K!).

C. minuticulmis S. W. Su & S. M. Xu，Bull. Bot. Res.，Harbin 8(3): 79，fig. 3. 1988. TYPE: China，Anhui，Taihu，28 Apr 1979，S. W. Su 2477 (holotype，ANU!，transferred to ACM!).

C. shanghaiensis S. X. Qian & Y. Q. Liu，Acta Phytotax. Sin. 37(1): 103，fig. 1. 1999. ——*C. blinii* H. Lév. & Vaniot subsp. *Shanghaiensis* (S. X. Qian & Y. Q. Liu) S. Yun Liang & T. Koyama in C. Y. Wu & al.，Fl. China 23: 387. 2010. TYPE: China，Shanghai，Shanghai Botanical Garden，27 Apr 1995，Y. Q. Liu & S. X. Qian 63 (holotype，PE!).

C. sublateralis T. Koyama，Jap. J. Bot. 15: 180. 1956. TYPE: China，Kiangsu (Jiangsu)，Suzhou，Mt. Shangfang，no date，K. Kimure s. n. (holotype，KYO!).

C. taihokuensis Hayata，Icon. Pl. Formosan. 10: 70. 1921. TYPE: China，Formosa (Taiwan)，near Taihoku (Taipei)，no date，U. Faurie s. n. (holotype，TI!; isotype，TI!).

C. tatsutakensis Hayata，Icon. Pl. Formosan. 6: 133，fig. 45. 1916. TYPE: China，Formosa (Taiwan)，Musha，Tatsutake，no date，W. R. Price 797 (holotype，TI!).

Rhizomes ligneous，thick，short. Culms lateral，tufted，(2–)5–10(–25) cm tall，trigonous，smooth or scabrous on upper part，with dark purple or purple fibrous sheaths at base. Leaves much longer than culms; blades flat，2–8 mm wide，soft or slightly stiff，smooth or scabrous on upper part. Involucral bracts leaf-like，almost not-sheathed. Spikes 2–4，crowded，nearly capitate; terminal spike staminate，linear-cylindrical，4–10 mm long，many-flowered; lateral spikes pistillate，oblong，broadly ellipsoid，ovoid or nearly globose，5–12×4–5 mm，loosely 2–7-flowered; peduncles short，enclosed in sheath，or lowermost one slightly exserted. Staminate scales elliptic-ovate to ovate，3.5–5 mm long，obtuse or acuminate at apex，green 3-veined costa on dorsal surface. Pistillate scales elliptic，lanceolate-ovate to broadly ovate，2–4 mm long，pale green or greenish yellow，reddish brown laterally，acute or acuminate at apex，green 3-veined costa excurrent into a short mucro or awn. Perigynia ovoid to nearly globose (excluding beaks)，obtusely trigonous，(3–)5–7 mm long，longer than pistillate scales，greenish yellow or yellowish brown，purple punctate on upper part，distinctly or inconspicuously veined，nearly glabrous or sparsely pubescent，gradually contracted into a beak at apex; orifice 2-lobed with minute teeth. Stigmas 3; style thickened at base. Achenes tightly enveloped，ovoid or broadly ovoid，trigonous，yellowish brown or castaneous，2.5–3 mm long，sides slightly concave，excavate or obtuse at apex，erect or curved stipitate at base. Fl. and fr. March–May.

Distribution Eest，Central，South and Southwest China，Philippines and Thailand.

Additional specimens examined

CHINA. Guangxi: Hechi，Dongnanwang，L. Q. Chen 92156 (IBK). **Guizhou**: Libo，Daqikong，X. F. Jin & al. 2388 (HTC)，2390 (HTC). Hainan: Wuzhishan，Mt. Nanle，Ng Sai Chit 5125 (IBSC). **Hubei**: Hefeng，Pingxi，Sangzhi For. Ins. 531 (KUN). **Sichuan**: Yanyuan，Bailing，Qing-zang Exped. 12871 (KUN). **Taiwan**: Chiayi，Mt. Arisan，anonymous 94 (TI)，U. Faurie 19 (P). Hsingchu，Chienshih，P. F. Lu 9593 (HAST). Hualien，Hsiulin，Y. Y. Huang & al. 622 (HAST). Nantou，Jenai，Wushe，W. C. Leong 2001 (HAST)，2018 (HAST); Mt. Lianhua，T. Koyama & al. 13787 (TI). Pingtung，Lilungshan，W. C. Leong 2281 (HAST); Manchou，Laofoshan，C. H. Liu & al. 353 (HAST). Taitung，Peinan，W. C. Leong 2697 (HAST); without precise locality，J. Ohwi 1388 (KYO). Taipei，Tatungshan，W. C. Leong 773 (HAST); Wenshan，J. Ohwi 570 (KYO)，617 (KYO)，774 (KYO). Urai，U. Faurie 12 (KYO)，19 (KYO). **Yunnan**: Funing，Lungmai，C. W. Wang 88878 (KUN). **Zhejiang**: Hangzhou，H. Wang & X. F. Jin 1444 (HTC)，1446 (HTC). Lin'an，Changhua，X. F. Jin & Y. Y. Zhou 3050 (HTC)，3051 (HTC). Yueqing，Mt. Yandang，X. F. Jin & P. J. Cao 1529 (HTC)，1533 (HTC). **PHILIPPINES. Canlaon**: Volcano，Negros，E. D. Merrill 6972 (BM，K，P). **Luzon**: Kalinga，Lubuagan，M. Ramos & E. Edano 37573 (BM，K); Laguna，Mt. Banajao，E. D. Merrill 8025 (BM，K). **Mindoro**: Mt. Calavite，M. Ramos 39401 (K，P). **TAILAND**. **Chaiyaphum**: Ban Nam Phrom.，R. Geesink & al. 6920 (KYO); C. F. von Beusekom & al. 4075 (KYO).

3.2 *C. oxyphylla* Franch.，Nouv. Arch. Mus. Hist. Nat.，III，10: 57. 1898. TYPE: China，Yunnan: Langcang (Lancang)，5 Jun 1886，Delavey 2524 (holotype，P!; isotype，E!). Fig 5: G，H

C. canaliculata P. C. Li，Acta Bot. Yunnan. 12: 148. 1990. TYPE: China，Yunnan: Weixi，Xinhua，19 May 1982，Qinghai-Xizang Exped. 6584 (holotype，PE!; isotypes，KUN!，PE!).

C. changmuensis Tang & F. T. Wang ex Y. C. Yang，Fl. Xizang. 5: 410，fig. 234. 1987. TYPE: China，Xizang，Nielamu，Changmu，6 May 1966，Y. T. Chang & K. Y. Lang 3227 (holotype，PE!)，not 3221.

C. distantiflora Nakai，Repert. Spec. Nov. Regni Veg. 13: 245. 1914. TYPE: Korea，Cheju Isl. 20 May 1913，1332 (lectotype，TI!).

C. infossa C. P. Wang，J. Nanjing Univ. (Biol.) 1962 (2): 52. 1962. TYPE: China，Anhui，Chuzhou，Mt. Langya，2 Jun 1957，C. P. Wang 76 (holotype，N!; isotype，N!).

C. infossa C. P. Wang var. *extensa* S. W. Su，J. Anhui Univ.，Nat. Sci. Ed. 20(3): 108. 1996. TYPE: China，Anhui，Qimen，Chawan，7 May 1982，S. W. Su 82005 (holotype，ANU; isotype，N!).

C. jackiana Boott f. *oxyphylla* (Franch.) Kük.，Pflanzenr. IV，20(38): 638. 1909.

C. lateralis Kük.，Pflanzenr.，IV，20(38): 639. 1909. TYPE: Ceylon，Obere Bergregion，no date，Thwaites 3198 (holotype，K!).

C. loheri C. B. Clarke，J. Linn. Soc.，Bot. 37: 14. 1904. TYPE: Philippines，Benguet，no date，A. Loher 701 (holotype，K!).

C. longirostrata C. A. Mey. var. *exaristata* X. F. Jin & C. Z. Zheng，Acta Phytotax. Sin. 42(6): 548. 2004. TYPE: China，Zhejiang，Yueqing，Mt. Yandang，28 Apr 1980，Q. C. Chen & J. H. Zhou 1879 (holotype，HZU!; isotype，PE!).

C. longirostrata C. A. Mey. var. *hoi* Chü ex S. Yun Liang，Acta Phytotax. Sin. 36(6): 537. 1998. TYPE: China，Zhejiang，Zhenhai，Chengwan，no date，Y. Y. Ho 943 (holotype，PE!).

C. lyi H. Lév. & Vaniot，Repert. Spec. Nov. Regni Veg. 3: 349. 1907. TYPE: China，Kouy-Tcheou (Guizhou)，Pinfa (Pingfa)，26 Apr 1909，J. Cavalerie 2329 (holotype，P!; isotype，E!).

C. macrandrolepis H. Lév. & Vaniot，Repert. Spec. Nov. Regni Veg.5: 241. 1908. TYPE: Korea，Isl. Quelpaert，May 1907，U. Faurie 2285 (holotype，P; isotype，KYO!).

C. sharyotensis Hayata，Icon. Pl. Formosan. 10: 69，fig. 46. 1921. TYPE: TYPE: China，Taiwan，Sharyoto，19 Mar 1916，B. Hayata s. n. (holotype，TI!).

Rhizomes ligneous，thick，short，sometimes with slender stolons. Culms central，rarely lateral，(10–) 20–40 cm tall，trigonous，smooth，with dark brown bladeless sheaths at base. Leaves slightly longer than culms，or almost equal in length; blades flat，2–6 mm wide，soft，smooth or scabrous on upper part. Involucral bracts leaf- like or shortly

leaf-like，short-sheathed to conspicuously sheathed; sheaths 3–25 mm long. Spikes 3–5，remote，or distal two crowded and others remote; terminal spike staminate，linear-cylindrical，5–30 mm long，many flowered; lateral spikes pistillate，oblong or cylindrical，8–20×ca. 4 mm，loosely 5–10-flowered; upper peduncles enclosed in sheath，lower ones exserted. Staminate scales ovate to lanceolate-ovate，5–5.5 mm long，acuminate at apex，green 3-veined costa on dorsal surface. Pistillate scales lanceolate-ovate，oblong-ovate，ovate to obovate，3.5–4 mm long，pale green or greenish yellow，reddish brown laterally，emarginate or acuminate at apex，green 3-veined costa excurrent into a short mucro or awn. Perigynia ellipsoid-obovoid，obovoid or ovoid (excluding beaks)，obtusely trigonous，4–6 mm long，longer than pistillate scales，greenish yellow or yellow，purple punctate on upper part，distinctly or inconspicuously veined，nearly glabrous or sparsely pubescent，gradually contracted into a beak at apex; orifice 2-lobed with minute teeth. Stigma 3; style thickened at base. Achenes tightly enveloped，ovoid，broadly ovoid or obovoid，trigonous，yellowish brown or castaneous，2.5–3.5 mm long，sides slightly concave，excavate or obtuse at apex，erect or curved stipitate at base. Fl. and fr. April-June.

Distribution East，Central，Southwest China，Japan，South Korea，India and Philippines.

Additional specimens examined

CHINA. Anhui: Chuzhou，Mt. Langya，S. W. Su 81065 (ACM); anonymous s. n. (ACM). **Guizhou:** Pingfa，J. Cavalerie 2325 (E). **Jiangsu:** Jurong，Mt. Baohua，C. P. Wang 72 (NAS). **Taiwan:** Taipei，Mt. Nankou-taisan，J. Ohwi 2505 (KYO，SYS); Shangto，J. Ohwi 154 (TI); without precise locality，J. Ohwi 182 (KYO)，s. n. (KYO). **Yunnan:** Fugong，Mt. Biluoxueshan，Qinghai-Xizang Exped. 7029 (PE). Lushui，Luma，Beijing Hengduan Exped. 245 (PE); Mt. Gaoligongshan，Beijing Hengduan Exped. 47 (PE)，356 (PE). Weixi，Yezhi，Naluo，Qinghai-Xizang Exped. 6352 (PE). **Zhejiang:** Hangzhou，Huanglongdong，H. Wang & X. F. Jin 1445 (HTC). Pan'an，Huaxi，X. F. Jin 2696 (HTC). **KOREA.** Cheju Isl.，T. Nakai 941 (TI). **JAPAN. Pref. Chiba**: Isumi-gun，Misaki-cho，T. Makino 224536 (KYO). **Pref. Ehime**: without precise locality，J. Oda 1942 (KYO). **Pref. Hyogo**: Mihara-gun，Nandan-cho，N. Fukuoka & N. Kurosaki 10317 (KYO，TI). **Pref. Kagoshima**: Satuma，Yamakawa-cho，T. Hatsusima 29935 (KYO，TI). **Pref. Kochi**: Takaoda-prov.，Kubokawa Town，T. Miyazaki 605160 (TI)，605180 (TI)，605187 (TI). **Pref. Kumamoto**: Kamimatsukuma，K. Mayebara 34 (TI)，207 (KYO). **Pref. Nagasaki**: Tsushima-shi，Izuhara-cho，T. Hoshino & al. 21281 (KYO). **Pref. Nara**: Nara-shi，Mt. Kasuga，K. Seto 47219 (KYO). Kasugayama，Y. Tsujikuma s. n. (TI). **Pref. Saga**: Karatsu-shi，Yobuko-cho，T. Hoshino & al. 21757 (KYO，TI). **Pref. Shizouka**: Shizouka-shi，J. Sugimoto s. n. (KYO，TI). **INDIA. Coonoor Lambrock:** Nilgiris，S. S. Hooper & C. Saldanda 18149 (K)，C. Townsend & T. P. Ramamoorthy 70 (K). **PHILIPPINES. Luzon**: Benguet，Baguio，A. D. E. Elemer 8582 (E，K); Quezon，J. S. Sands s. n. (K).

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Appendix.

Voucher specimens which perigynia and achenes gathered. [Taxa, vouchers (collector, collected number and herbarium), locality-perigynium-achene]

Carex blinii H. Lév. & Vaniot (sample 1): X. F. Jin & al. 2388, HTC; China, Guizhou, Libo-perigynium-achene. ***C. blinii*** H. Lév. & Vaniot (sample 2): X. F. Jin & al. 2390, HTC; China, Guizhou, Libo-perigynium. ***C. minuticulmis*** S. W. Su & S. M. Xu: S. W. Su 2477, ACM; China, Anhui, Taihu-perigynium-achene. ***C. taihokuensis*** Hayata: J. Oda 1747, KYO; Japan, Okinawa Pref., Ishigaki-shi-perigynium-achene. ***C. tatsutakensis*** Hayata: J. Ohwi 169, KYO; China, Taiwan, Taipei-perigynium-achene. ***Carex. tatsutakensis*** Hayata (sample 2): anonymous 94, TI; China, Taiwan, Chiayi, Mt. Arisan-achene. ***C. infossa*** Z. P. Wang:Z. P. Wang 72, NAS; China, Jiangsu, Jurong, Mt. Baohua-perigynium-achene (sample 1). ***C. infossa*** Z. P. Wang (sample 2):S. W. Su 81065, ACM; China, Anhui, Chuzhou, Mt. Langya-achene. ***C. infossa*** Z. P. Wang (sample 3):H. Wang & X. F. Jin 1445, HTC; China, Zhejiang, Hangzhou-achene. ***C. infossa*** Z. P. Wang var. ***extensa*** S. W. Su: anonymous s. n., ACM; China, Anhui, Qimen-perigynium. ***C. lateralis*** Kük.: E. D. Merrill 6972, P; Philippines, Canlaon, Volcano. ***C. longirostrata*** C. A. Mey. var. ***exaristata*** X. F. Jin & C. Z. Zheng: Q. C. Chen & J. H. Zhou 1879, HZU; China, Zhejiang, Yueqing, Mt. Yandang-perigynium-achene. ***C. longirostrata*** C. A. Mey. var. ***hoi*** S. Yun Liang: Y. Y. Ho 943, PE; China, Zhejiang, Zhenhai-perigynium-achene. ***C. macrandrolepsis*** H. Lév. (sample 1): J. Ohwi 2505, KYO; China, Taiwan, Taipei-perigynium-achene. ***C. macrandrolepsis*** H. Lév. (sample 2): T. Hoshino & al. 21757, TI; Japan, Saga Pref., Karatsu-shi-perigynium-achene. ***Carex oxyphylla*** Franch.: Delavey 2524, P; China, Yunnan, Lancang-perigynium. ***C. sharyotensis*** Hayata: B. Hayata s. n., TI; China, Taiwan, Sharyoto-perigynium.