

## Taxonomic study of Pan-Himalayan *Cyperus* species which used to be placed in the segregate genus *Pycreus*

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

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
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### Abstract

This paper presents a taxonomic account of the *Cyperus* species which used to be placed in the segregate genus *Pycreus* (hereafter: *Pycreus* species) within the Pan-Himalaya, based on morphological and micromorphological studies. Twelve *Pycreus* species have been identified in the Pan-Himalaya region. Taxonomic keys, descriptions, type information, ecology, and distribution notes are provided for each species. The taxonomic significance of nutlet micromorphology is discussed, supported by high-quality digital images and scanning electron microscope (SEM) observations. *Cyperus diaphanus* var. *gracilescens* and *Pycreus pseudolatespicatus* are synonymized with *C. diaphanus*. A new combination is proposed for *P. lijiangensis*, and lectotypes are designated for *C. angulatus*, *C. diaphanus*, *C. substramineus*, *C. sulcinus*, *C. delavayi* and *P. lijiangensis*. Additionally, *C. africanus* is reported for the first time outside Africa.

**Key words:** Cyperaceae, *Cyperus africanus*, lectotype, Nepal Himalaya, new combination, synonym, SEM, typification, weeds

### Introduction

The genus *Cyperus* Linnaeus (1753: 44), encompassing more than 950 species, belongs to the cosmopolitan family Cyperaceae (Larridon *et al.* 2021). Recently, the taxonomy of *Cyperus* has undergone revision, incorporating 13 previously recognized segregate genera into a more broadly defined genus *Cyperus*, including *Pycreus* Beauvois (1816: 48) (Bauters *et al.* 2014, Larridon *et al.* 2011, 2013, 2014, Pereira-Silva *et al.* 2020). *Pycreus* species display C4 photosynthesis and Kranz anatomy (Vrijdaghs *et al.* 2011). They are characterized by an antheloid inflorescence, having flattened spikelets with distichously arranged glumes, each subtending a bisexual flower producing biconvex nutlets (Dai *et al.* 2010, Goetghebeur 1998, Vrijdaghs *et al.* 2011).

The complexity of the genus *Cyperus* poses challenges in establishing reliable subdivisions, as indicated by Larridon *et al.* (2013). The classification of *Pycreus*, encompassing approximately 114 species, faces issues of incomplete understanding (Larridon *et al.* 2013, 2014), and the determination of their position within *Cyperus* requires careful observations of morphology.

There are about 50 *Pycreus* species in Asia (Dai *et al.* 2010, Koyama 1978, 1985, Shrestha *et al.* 2022). Their taxonomic status is currently unclear (Larridon *et al.* 2014) and needs to be revised. For example, a re-evaluation is essential for the *Pycreus diaphanus* complex; *Pycreus lijiangensis* requires a valid name in *Cyperus*, and several names

need to be lectotypified. This paper reports a comprehensive taxonomic account of the *Pycnus* species across the Pan-Himalaya region, including morphological descriptions with images of both spikelets and nutlets, type information, ecological insights, distribution notes, and a key to species.

## Materials & Methods

### Sample collection, herbarium specimen study and identification

This study was conducted in the Pan-Himalaya, which includes northeastern Hindu-Kush, Karakoram, Himalaya, and Hengduan mountains (Wang & Hong 2022). The Pan-Himalaya is divided into 17 subregions, extending from areas of Afghanistan in the west to China's Yunnan Province in the east (Jin *et al.* 2020). We have utilized these geographical subregions for the distribution information of *Cyperus* species.

This work is a combination of living plant collection, examination of herbarium specimens, and a review of relevant literature. Live plants were collected from their natural habitats, with a focus on locations such as the Nepal Himalayas and parts of the Xizang Autonomous Region in China. CAL, DD, KATH, PE and TUCH were visited in person. Digital images of specimens deposited at BM, BR, C, CDBI, E, HNWP, IBSC, JE, K, K-W, KUN, L, LD, LINN, MA, MICH, MPU, MW, NY, P, SING, TI, UPS and US (acronyms following Thiers 2023 onwards) were consulted through their respective herbaria online portals, as well as through resources like the Chinese Virtual Herbarium (CVH, <https://cvh.ac.cn>), Global JSTOR (<https://plants.jstor.org/>), and the Global Biodiversity Information Facility database (GBIF, <https://gbif.org>).

Plant identification was accomplished by consulting monographs, regional floras, and national checklists (Dai *et al.* 2010, Koyama 1978, 1985, Kükenthal 1936, Shrestha *et al.* 2022). Descriptions of individual taxa are based on the study of 400 live collections and herbarium specimens, although only representative specimens are cited in the 'Specimens Examined' sections. Spikelet, glume, and nutlet characteristics were observed using a stereomicroscope (Nikon SMZ1270 and Leica DVM6). The measurement tool within Global JSTOR was utilized to measure the plant size, particularly for type specimens.

### Scanning electron microscope (SEM) study

A SEM study was conducted following the procedure outlined by Lu *et al.* (2017). The mature nutlets were treated with a mixture of acetic anhydride and concentrated sulfuric acid (in a 9:1 ratio) for 3 to 4 hours, followed by rinsing in acetic acid for 10 minutes. The acetolyzed nutlets were then washed with distilled water for 5 minutes and subjected to a 10-minute bath-type ultrasonic cleaning using 70% ethanol. After cleaning, the nutlets were air-dried, affixed onto the double-sided adhesive tape, and sputter-coated with a layer of gold using a Hitachi E-1010 Ion Sputter Coater for 70 seconds. Observation and photography of the nutlets were carried out using a Hitachi S-4800 scanning electron microscope, operating at 10.0KV. Silica bodies were categorized following the terms outlined by Reynders (2013).

## Results and discussion

The morphological and micromorphological studies of the *Pycnus* species revealed 12 species in the Pan-Himalaya. *Cyperus diaphanus* var. *gracilescens* and *P. pseudolatespicatus* are synonymized with *C. diaphanus*. A new combination is proposed for *P. lijiangensis*, and lectotypes are designated for *C. angulatus*, *C. diaphanus*, *C. substramineus*, *C. sulcinus*, *C. delavayi* and *P. lijiangensis*. Additionally, *C. africanus* is reported for the first time outside Africa.

## Morphology

### Habit and Habitat

All the here studied species are annual or short-lived perennial herbs, with the potential to become weedy. They



thrive in diverse habitats such as paddy fields, wetlands, roadsides, and abandoned lands, covering elevations ranging from 60 meters to nearly 4000 meters above sea level. *Cyperus diaphanus*, *C. flavidus*, and *C. sanguinolentus* show dominance from lowlands to high elevations. In contrast, *C. pumilus* and *C. substramineus* are primarily found in lowland areas. Species such as *C. africanus*, *C. delavayi*, *C. flavescens*, *P. lijiangensis*, and *C. unioloides* prefer mid-altitudes within montane regions. Moreover, *Cyperus africanus*, *C. diaphanus*, *C. flavidus*, *C. sanguinolentus* and *C. sulcinux* have been observed to display weedy characteristics, particularly by encroaching into agricultural lands, notably paddy fields.

### **Culm and leaves**

The culms are terete, smooth, and 3-angled, varying in height from 2 cm to 70 cm. *Cyperus africanus*, *C. delavayi*, *C. flavidus*, *C. polystachyos*, *C. sanguinolentus*, and *C. unioloides* possess rigid culms that can reach up to 70 cm in height. *Cyperus diaphanus* exhibits considerable variability in plant height, ranging from 2 cm to 32 cm. On the other hand, *C. pumilus* is notably shorter, often measuring less than 10 cm. In contrast, *P. lijiangensis*, *C. substramineus*, and *C. sulcinux* display intermediate plant heights, falling within the range of 10 to 24 cm. The leaves can be either flat or canaliculate and may be shorter or longer than the culm.

### **Inflorescence**

The inflorescence is a simple anthela, with spikelets arranged in rays or forming a capitate structure. *Cyperus africanus* and *C. substramineus* feature a spicate inflorescence with sub erect spikelets. The sub erect spikelet is also a characteristic of *C. polystachyos*, but its spikelets are arranged in a capitulum. *Cyperus delavayi* and *C. unioloides* have spreading spikelets, organized in rays of unequal length. *Cyperus diaphanus*, *C. flavidus* and *C. sanguinolentus* exhibit extreme variation in the number of inflorescence rays, which can be either absent, very short, or longer than the inflorescence. While *Pycnus lijiangensis* is morphologically related to *C. flavidus*, it differs by having very short inflorescence rays.

### **Spikelets**

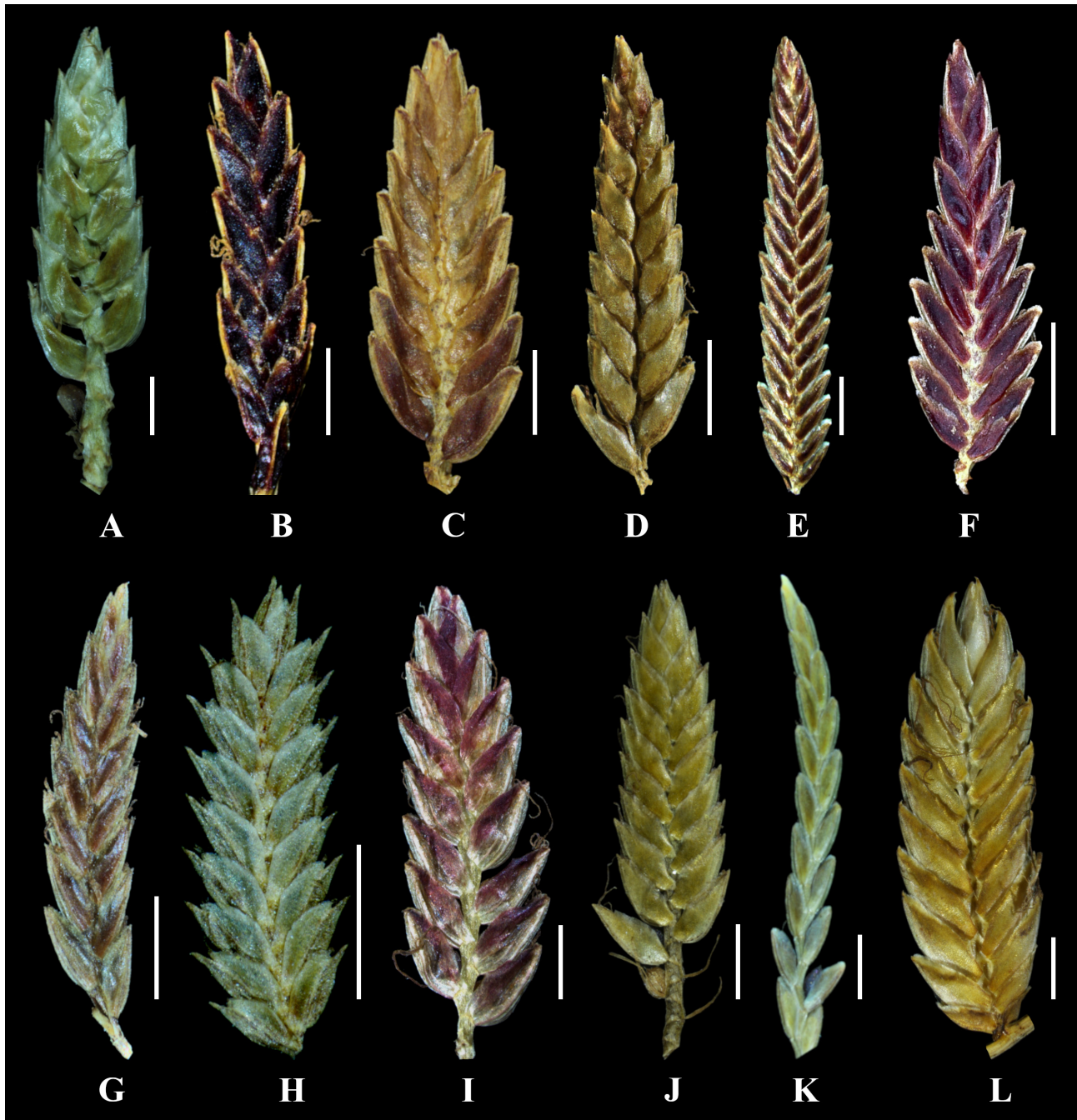
Spikelets are oblong-lanceolate (*Cyperus africanus*, *C. delavayi*, *C. diaphanus*, *C. sanguinolentus*), linear-oblong (*C. flavescens*, *C. flavidus*, *C. pumilus*, *C. substramineus*), linear-lanceolate (*C. sulcinux*), oblong-obovoid (*C. polystachyos*) or ovoid (*P. lijiangensis*) (Fig. 1).

### **Glumes**

Glumes are arranged distichously, either loosely or tightly imbricated. Species growing in low elevations have pale brown or brownish glumes. Stramineous-yellowish glumes are a distinctive characteristic of *C. substramineus*. While *C. delavayi* and *P. lijiangensis* exhibit a superficial similarity in spikelet colour to certain forms of *C. flavidus*, the presence of dark-coloured glumes is often associated with *Cyperus* species growing at higher elevations (Larridon *et al.* 2013, 2014).

### **Nutlet**

The nutlets exhibit a range of shapes, including globose (*C. africanus*), oblong (*C. delavayi*, *C. pumilus*, *C. sulcinux*), oblong-obovoid (*C. delavayi*, *P. lijiangensis*, *C. polystachyos*, *C. pumilus*), narrowly obovoid (*C. flavescens*, *C. flavidus*, *C. pumilus*) to broadly obovoid (*C. diaphanus*, *C. sanguinolentus*, *C. substramineus*, *C. unioloides*). Their colour varies from blackish and shiny brownish to reddish brown, brownish black, and greyish black (Fig. 2, 3, 4). The majority of species have symmetrical nutlets, whereas those of *Cyperus africanus* display an obliquely globose form. *Pycnus lijiangensis* also has notably asymmetric nutlets, with the upper ridges consistently curving inwards (Fig. 3D). This unsymmetrical shape likely results from being pressed against the rachilla.



**FIGURE 1.** Spikelets diversity in *Pycreus* species in the Pan-Himalaya (A: *Cyperus africanus*; B: *C. delavayi*; C: *C. diaphanus*; D: *C. flavescens*; E: *C. flavidus*; F: *C. lijiangensis*; G: *C. polystachyos*; H: *C. pumilus*; I: *C. sanguinolentus*; J: *C. substramineus*; K: *C. sulcinux*; L: *C. unioides*). [Scale bar = 2 mm]

### *Micromorphology*

We utilized SEM to observe the nutlet micromorphology of all *Pycreus* species within the Pan-Himalaya. The micromorphology of nutlet is considered an important taxonomic characteristic in Cyperaceae. Nutlet micromorphology has found application in both subgeneric (Kükenthal 1936, Reynders 2013) and species-level taxonomy (Reynders & Goetghebeur 2010) of *Pycreus*. The nutlet surface, epidermal cell shape, the nature of anticlinal and periclinal walls, and the presence or absence of silica bodies play a significant role in resolving taxonomic issues. Within the Cyperaceae family, two primary types of nutlet epidermal cells are recognized: isodiametric cells with relatively uniform length and width, and zonate cells characterized by longitudinally elongated cells (Clarke 1893, Kükenthal 1936, Reynders 2013, Reynders & Goetghebeur 2010), which is well represented in Pan-Himalayan *Pycreus* species. A comparison of the micromorphological nutlet characteristics is presented in Table 1 and Fig. 2, 3, and 4.

**TABLE 1.** Comparison of nutlet micromorphology of *Pycurus* species in the Pan-Himalaya.

Species	Nutlet			Epidermal cell		Anticlinal wall	Periclinal wall and silica bodies
	shape	surface	size (mm)	shape	size (µm)		
<i>Cyperus africanus</i>	obliquely globose, turgid	punctate	1.2–1.8 × 1.2–1.4	isodiametric - hexagonal	24.7–48.4 × 17.9–25.9	straight	smooth; satellites and silica bodies absent
<i>Cyperus delavayi</i>	oblong-obovoid	punctate	1.3–1.8 × 0.6–0.9	isodiametric - hexagonal	30.7–49.9 × 28.4–38	straight	satellites absent; a central tubular silica body present
<i>Cyperus diaphanus</i>	obliquely globose-obovoid	transversely striate	1–1.2 × 0.9–1	zonate	138–174.0 × 11.1–15.0	straight	surface granulated with knobby apex satellites; central silica body absent
<i>Cyperus flavescentis</i>	ellipsoid-obovoid	transversely striate	1–1.1 × 0.6–0.7	zonate	57.4–102.4 × 10.1–19.2	straight	smooth; satellites and silica body absent
<i>Cyperus flavidus</i>	obovoid, biconvex	punctate	0.8–1 × 0.5–0.6	isodiametric - hexagonal	18.8–25.09 × 16.70–24.04	straight or repand	satellites absent; a rounded and knobby apex silica body present
<i>Cyperus lijiangensis</i>	oblong-obovoid	punctate	0.7–1.1 × 0.4–0.6	isodiametric - hexagonal	18.7–39.4 × 17.5–25.5	straight with granules attached	surface granulated; a central rounded and knobby apex silica body present
<i>Cyperus polystachyos</i>	narrowly oblong-obovoid	punctate	0.8–1 × 0.4–0.5	isodiametric - hexagonal	22.86–29.19 × 20.31–25.02	straight	satellites absent; a tabular and smooth apex silica body present
<i>Cyperus pumilus</i>	oblong to narrowly obovoid	punctate	0.5–0.7 × 0.4–0.5	isodiametric - hexagonal	21.75–29.96 × 20.54–25.61	sinuous	surface granulated; a central tabular silica body present
<i>Cyperus sanguinolentus</i>	obovoid-globose	punctate	0.8–1 × 0.6–0.8	irregular-hexagonal	19.55–35.78 × 19.63–35.95	straight	satellites absent; a reduced central tabular silica body present
<i>Cyperus substramineus</i>	broadly obovoid, biconvex	transversely wavy wrinkled	0.9–1 × 0.7–0.8	zonate	34.77–71.33 × 11.44–18.28	straight	smooth, satellites and silica body absent
<i>Cyperus sulcinus</i>	oblong, furrow on each side	punctate	1.2–1.4 × 0.5–0.6	isodiametric - hexagonal	29.23–44.82 × 19.24–26.62	straight	satellites absent; a tabular and smooth apex silica body present
<i>Cyperus unioloides</i>	broadly obovoid, biconvex	punctate	1–1.3 × 0.7–1	isodiametric - hexagonal	29.55–49.88 × 22.56–34.97	straight	satellites absent; a narrow central tabular silica body present

*Cyperus diaphanus*, *C. flavescentis*, and *C. substramineus* possess nutlets with zonate cells, characterized by longitudinally stretched oblong epidermal cells that give a distinctive transverse striation or wavy appearance. The elongation of epidermal cells is less pronounced in *C. flavescentis* but is distinct in the other two species. Furthermore, in *C. diaphanus*, the periclinal wall displays numerous satellites, while such structures are absent in both *C. flavescentis* and *C. substramineus*. *Cyperus africanus*, *C. delavayi*, *C. flavidus*, *P. lijiangensis*, *C. polystachyos*, *C. pumilus*, *C. sulcinus*, *C. sanguinolentus* and *C. unioloides* all have nutlets with punctate surfaces and isodiametric epidermal cells.

In the case of *C. africanus*, its nutlets are turgid and notably lack silica bodies in their epidermal cells. On the other hand, the nutlets of *C. delavayi*, *C. polystachyos*, and *C. sulcinus* feature a central tabular silica body within their epidermal cells. In contrast, *C. flavidus* and *P. lijiangensis* have nutlets with a knobby apex silica body. Furthermore, in the case of *P. lijiangensis*, the central silica body is surrounded by granulated satellites. *Cyperus pumilus* possesses nutlets with a tabular apex silica body, which is surrounded by granulated satellites. Lastly, both *C. sanguinolentus* and *C. unioloides* display nutlets with a narrow central tabular silica body, but they lack satellites.

The classification of the *Pycurus* group within *Cyperus* remains unresolved and is not considered monophyletic. We were unable to classify the Pan-Himalayan species into specific sections. Nevertheless, this study reveals that stable traits such as spikelet arrangements, nutlet shape, and epidermal cell structure can be employed for the infrageneric classification of *Cyperus*. These characteristics can be integrated with data from anatomy, embryology, ontogeny, and molecular evidence to develop a more comprehensive classification system.

## Taxonomic treatment

### Key to *Pycreus* species in the Pan-Himalaya

- 1a. Nutlet surface transversely striate, epidermal cells oblong and longitudinally stretched .....2
- 1b. Nutlet surface punctate, epidermal cells isodiametric .....4
- 2a. Spikelets sub erect, glumes stramineous ..... *C. substramineus*
- 2b. Spikelets spreading, glumes yellowish brown to reddish-brown .....3
- 3a. Spikelets ovate-lanceolate, glumes > 2 mm long, nutlet greyish-black, globose-obovoid ..... *C. diaphanus*
- 3b. Spikelets linear-oblong, glumes ≤ 2 mm long, nutlet shiny brown, ellipsoid-obovoid ..... *C. flavescens*
- 4a. Spikelets erect or sub erect, nutlet broadly elliptic-globose, strongly swollen ..... *C. africanus*
- 4b. Spikelets sub erect or spreading, nutlet elliptic, linear-oblong to obovoid .....5
- 5a. Lower part of culm with nodes, glumes furrowed on either side of midvein ..... *C. sanguinolentus*
- 5b. Lower part of culm lacking nodes, glumes not furrowed on either side of midvein .....6
- 6a. Glumes apex emarginated and excurved mucronate ..... *C. pumilus*
- 6b. Glumes apex acute or obtuse and not excurved mucronate .....7
- 7a. Spikelets linear-oblong, oblong-ovoid or narrowly ovoid, 2.4–5 mm wide, stamens 3 .....8
- 7b. Spikelets linear-oblong, linear-lanceolate, linear-ovoid, oblong or narrowly elliptic, 1–2.7 mm wide, stamens 1 or 2 .....9
- 8a. Spikelets narrowly ovoid to linear-oblong, 2.4–3.8 mm wide, glumes dark reddish, nutlet oblong to narrowly obovoid ..... *C. delavayi*
- 8b. Spikelets narrowly ovoid to oblong ovoid, 3–5 mm wide, glumes straw coloured, nutlet globose-obovoid to broadly obovoid ..... *C. unioloides*
- 9a. Spikelets linear-lanceolate, glumes loosely imbricate, nutlet with a shallow furrow on each side ..... *C. sulcinus*
- 9b. Spikelets linear-oblong to narrowly ovoid, glumes tightly imbricate, nutlet lacking shallow furrows .....10
- 10a. Spikelets sub-erect, rachilla flexuose and narrowly winged, nutlet linear-oblong ..... *C. polystachyos*
- 10b. Spikelets spreading, rachilla straight and wingless, nutlet elliptic-obovoid or oblong-obovoid .....11
- 11a. Anthelate with short rays, < 2 cm long, spikelets ovoid to narrowly linear-ovoid, glumes abaxially not conspicuously keeled, nutlet obovoid-oblong ..... *C. lijiangensis*
- 11b. Anthelate usually with slightly long or short rays, usually > 2 cm long, spikelets linear-oblong, glumes abaxially keeled, nutlet narrowly obovoid ..... *C. flavidus*

*Cyperus africanus* (S.S. Hooper) Reynders in Larridon *et al.* (2014: 41) ≡ *Pycreus africanus* (S.S. Hooper) Reynders in Reynders & Goetghebeur (2010: 227) ≡ *Pycreus divulsus* subsp. *africanus* S.S. Hooper (1972: 579). Type:—CAMEROON, Gaudua, eastern foothills of the Gotel mountains, 17 July 1969, *J.Br. Hall 1381* (holotype: K [K000363026!], isotype: P [P00573023!]).

Short-lived perennial herbs. Culm tufted, 25–60 cm high, 1.6 mm wide. Leaves to 17 cm, 2–2.5 mm wide, shorter than inflorescence, glabrous except the apical part which is sparsely scabrous. Involucral bracts sub erect, 2 to 4, leaflike, longer than inflorescence, 2.5–13.5 cm × 1–2 mm, apical margin scabrous. Inflorescence a simple anthela with 2 to 5 sessile spikelets. Spikelets flat, lanceolate, 5–25 × 2–4 mm, erect to sub erect. Rachilla straight, winged. Glumes distichously arranged, loosely imbricate, ovate, 3–3.5 × 2.5–3 mm, yellowish-green to pale brown, glabrous, apical margin broadly hyaline, veins 3, middle one forming a greenish to light brownish keel, elongated into a mucro. Nutlet obliquely globose, 1.2–1.8 × 1.2–1.4 mm, black, smooth, punctate with isodiametric hexagonal cells. Style 2 mm long, stigmas 2, 1–1.5 mm long. Stamens 3, filament 2.2–2.5 mm long, anther oblong, 0.5–1 mm long.

**Phenology:**—Flowering and fruiting from August to November.

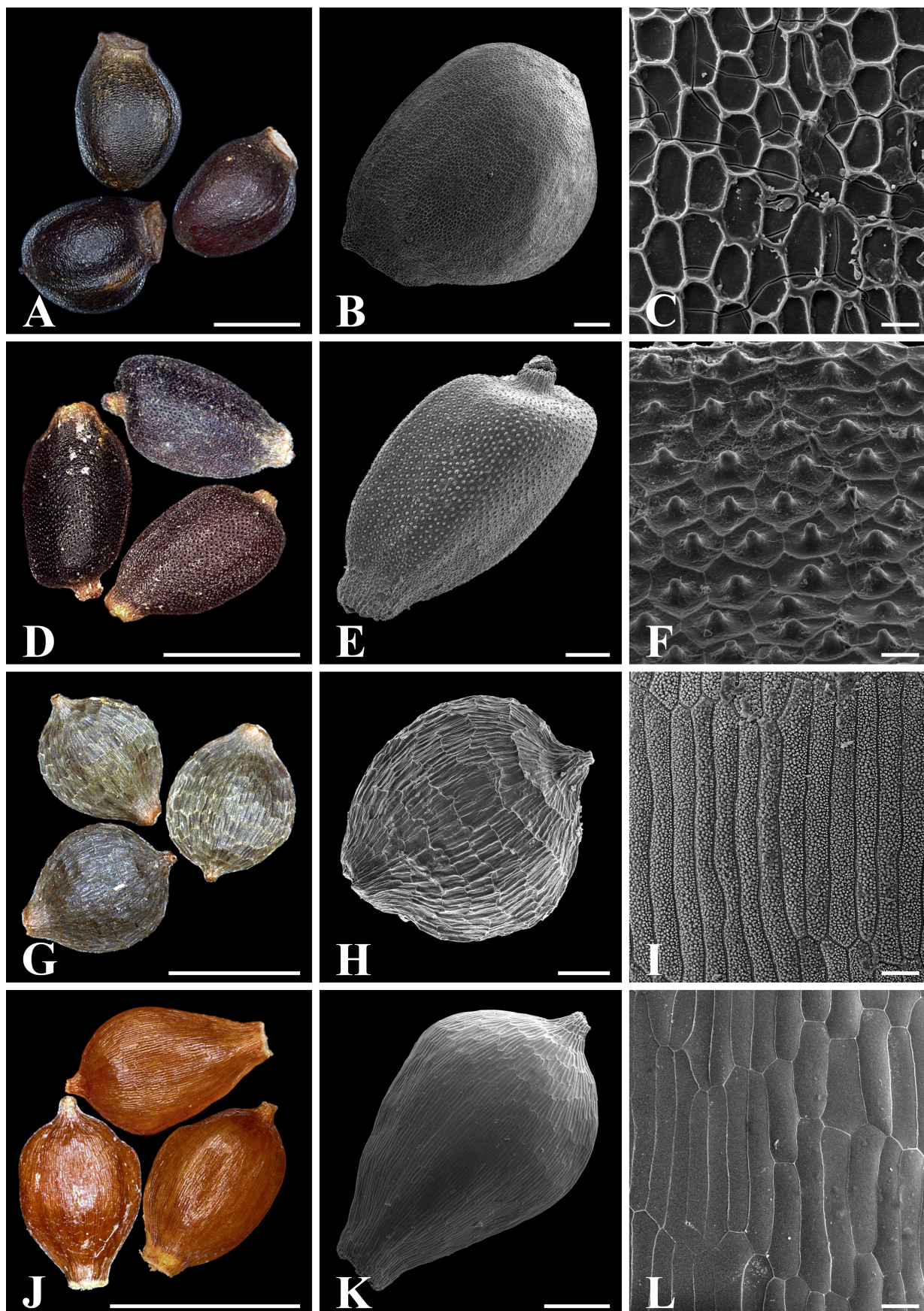
**Habitats:**—Grows along the gravelled roads, lake banks, edges of agricultural land, and montane grassland; 800–1765 m.

**Distribution:**—Pan-Himalaya (C Nepal, new distributional record) and Africa (Cameroon, Congo, Ethiopia, Nigeria and Sierra Leone).

**Notes:**—*Cyperus africanus* is allied with a Malagasy endemic '*Cyperus divulsus*' in its reduced, spicate inflorescence and turgid nutlets. Because of this, Hooper (1972) described it as an infraspecies of the latter. Reynders & Goetghebeur (2010) upgraded it to a specific rank based on its larger and smooth nutlets (Fig. 2A, 2B, 2C, 5).

The occurrence of *Cyperus africanus* is quite rare and isolated in medium altitudes throughout the African continent, where it is found mostly in montane grasslands (Reynders & Goetghebeur 2010). Its closest relative, *C. divulsus*, is widespread in Madagascar, preferring mid-altitude habitats along wet roadsides and rice field edges (Reynders & Goetghebeur 2010). The discovery of *C. africanus* in Pokhara Valley, Central Nepal, within the mid-hills of the lesser Himalayas, is rather surprising. The natural expansion of the taxon in the Himalayas should not be overlooked, especially considering the presence of several species from the core *Pycreus* clade (*Cyperus flavescens*, *C.*





**FIGURE 2.** Nutlet diversity in *Pycurus* species in the Pan-Himalaya (A, B, C: *Cyperus africanus*; D, E, F: *C. delavayi*; G, H, I: *C. diaphanus*; J, K, L: *C. flavescens*). [Scale bar: first column = 1 mm, second column = 200 µm, third column = 20 µm]



*flavidus*, *C. sanguinolentus*). It's possible that this species locally evolved as a result of smaller radiations originating from dispersal events, a phenomenon often observed in the *Cyperus* clade (Larridon *et al.* 2013) outside of Africa. Alternatively, considering its weedy nature, there's also the possibility of anthropogenic factors introducing African taxon to the Himalayas. The exact dispersal pathways remain a topic for further investigation.

**Specimens examined:**—C NEPAL. Gandaki, Kaski, Pokhara Valley, *P. Bhandari KAS21* (KATH); Gandaki, Kaski, Bhadaure Deurali, *P. Bhandari 219004* (TUCH); Gandaki, Parbat, Chitre village, *P. Bhandari 21100802* (KATH).

***Cyperus delavayi*** (C.B. Clarke) Kükenthal (1936: 331)  $\equiv$  *Pycneus delavayi* C.B. Clarke (1903: 203). Type:—CHINA, Yunnan, Mt. Cangshan, Dali, [Les rochers du Tsang Chan au-dessus de Ta-li] 04 July 1882, *J.M. Delavay 413* (lectotype designated here: P [P00526069!], isoelectotypes: P [P00697819!, P00697820!, P00697821!]).

Perennial herbs. Culm slender, tufted, 20–60 cm long, 1 mm wide, base clothed with brownish sheath. Leaves shorter to slightly longer than culm, 1–2 mm wide. Involucral bracts 2, leaflike, longer than inflorescence, 1.5–14 cm long, apical margin scabrous. Inflorescence terminal in a simple anthela. Rays 2 or 3, 0.3–1.6 cm long, producing 1 to 8 spikelets, or rays very short, giving capitate like spikelets. Spikelets linear-oblong to narrowly ovoid, 4.2–13  $\times$  2.4–3.8 mm, obliquely spreading, bearing 6 to 16 distichously arranged glumes. Rachilla straight, wingless. Glumes tightly to semi-laxly imbricate, ovate, 2–2.8  $\times$  1.6–2 mm, dark reddish, membranous, veins 3, middle one weakly keeled, apex acute, margin narrowly hyaline. Nutlet oblong to oblong-obovoid, 1.3–1.8  $\times$  0.6–0.9 mm, blackish, biconvex, densely punctulate. Stigmas 2, slender. Stamens 3, anthers linear, 1–1.2 mm long. (Fig. 2D, 2E, 2F)

**Phenology:**—Flowering and fruiting from May to July

**Habitats:**—Wet places; 1500 m.

**Distribution:**—Endemic (Pan-Himalaya: S Hengduan)

**Notes:**—In 1903, C.B. Clarke described *Pycneus delavayi* based on *Delavay 413*, which is housed at P. Upon checking the online database, it appears that *J.M. Delavay 413* has at least four duplicates at P. All four duplicates are well-preserved and exhibit the distinctive characteristics of the species. Moreover, P00526069, which bears the original collection label of *J.M. Delavay*, as well as manuscript notes and the annotations in Clarke's handwriting, has been designated as the lectotype following Art. 9.3 and 9.4 of the ICN (Turland *et al.* 2018).

*Cyperus delavayi* exhibits superficial similarity with some forms of *C. flavidus* in terms of spikelet colour. However, the dark-coloured glumes are more commonly linked with *Cyperus* species found at higher elevations (Larridon *et al.* 2013, 2014). Clarke (1903) allied *C. delavayi* with *C. aethiops* Welw. ex Ridl. (Synonym: *Pycneus cooperi* C.B. Clarke) in its large spikelets and loosely packed glumes. However, *C. aethiops*, as indicated by Browning *et al.* (2020), is a rigid plant characterized by elongated rays and is limited to Africa.

**Specimens examined:**—S HENGDUAN. Yunnan, *Anonymous 10413* (PEY [PEY0044077]). Yunnan, Dali (Ta li Hsien), *C.W. Wang 63429* (PE).

***Cyperus diaphanus*** Schrad. ex Schultes (1824: 477)  $\equiv$  *Cyperus latispicatus* var. *diaphanus* (Schrad. ex Schult.) Kükenthal (1936: 393)  $\equiv$  *Pycneus diaphanus* (Schrad. ex Schult.) S.S. Hooper & T. Koyama in Koyama (1976: 316). Type:—NEPAL, *N. Wallich s.n.* (lectotype designated here: K [K000592582!], isoelectotypes: BR [BR0000021901096!], SING [SING0064482!]).

$\equiv$  *Cyperus latespicatus* Boeckeler (1859: 441)  $\equiv$  *Pycneus latespicatus* (Boeckeler) C.B. Clarke (1893: 590)  $\equiv$  *Cyperus diaphanus* var. *latespicatus* (Boeckeler) J. Kern (1974: 653). Type:—East Bengal, Herb. Griffith. 6200 (L [L. 1373738!], NY [04328115!]).

$\equiv$  *Cyperus latispicatus* var. *acaulis* C.B. Clarke (1884: 41)  $\equiv$  *Pycneus diaphanus* var. *acaulis* (C.B. Clarke) Karthik. in Karthikeyan *et al.* (1989: 64). Type:—INDIA, Meghalaya, Cherra, Khasi, 1200 m, 26 November 1871, *C.B. Clarke 15165* (K [K000592583!]).

$\equiv$  *Cyperus diaphanus* var. *gracilescens* (Kük.) H.O. Saxena (1973: 505), *syn. nov.*  $\equiv$  *Cyperus latespicatus* var. *gracilescens* Kükenthal (1913: 93)  $\equiv$  *Pycneus diaphanus* var. *gracilescens* (Kük.) S.S. Hooper (1976: 692). Type:—INDIA, Shimogma Maisor, *A. Meebold 9353* (not located).

$\equiv$  *Pycneus plicatus* Govindarajalu (1990: 100). Type:—INDIA, Tamil Nadu, Madurai District, Venniar to Varaiyattumottai, High Wavys, 24 February 1978, *E. Govindarajalu 014125A* (holotype: CAL!).

$\equiv$  *Pycneus pseudolatespicatus* Dai in Tang & Wang (1961: 11. 173, 233), *syn. nov.* Type:—CHINA, Sichuan, *K.K. Tsoong 8416* (holotype: PE!).

Annual herbs. Culm rigid or slender, tufted to loosely tufted, 2–32 cm long, 0.5–1 mm wide, 3-angled. Leaves blade flat, shorter or longer than culm, 2–15 cm long, 1.2–2.6 mm wide, glabrous, entire. Involucral bracts 2 or 3, leaflike,

spreading, longer than inflorescence, 4–20 cm long, 1–2.4 mm wide, apex distantly scabrous. Inflorescence a simple anthela producing rays or forming a capitulum. Rays if present (0.6–)2–4.1 cm long, giving 2–11 spikelets. Spikelets spreading, ovate, narrowly oblong to lanceolate, 4–12.1 × 2.1–4.5 mm, bearing 8 to 20 flowers. Rachilla 4-sided, straight, wingless. Glumes tightly imbricate, ovate, 1.6–3.9 × 1–1.8 mm, yellowish brown to reddish brown, 3-veined, keel pale green and slightly winged, apex acute, margin narrowly hyaline. Nutlet broadly obovoid, 1–1.2 × 0.9–1.1 mm, greyish black, biconvex, transversely undulate striate, epidermal cells longitudinally oriented, shoulder distinct, apiculate. Style slender, 1.4 mm long, stigmas 2. Stamens 2, anther 0.5–0.6 mm long, linear-oblong. (Fig. 2G, 2H, 2I)

**Phenology:**—Flowering and fruiting from August to December.

**Habitats:**—A weed of paddy field, also grows near water bodies, in marsh places and streamlets bed; 641–3000 m.

**Distribution:**—Pan-Himalaya (U Ganga & Indus, W Nepal, C Nepal, E Nepal, Bhutan, Sichuan, Yunnan); also in Assam and Meghalaya (India), Bangladesh, Japan, Korea, Philippines, Thailand, Indonesia and Vietnam.

**Notes:**—Schultes (1824), in his description of *Cyperus diaphanus*, mentioned ‘Nepala’ [Nepal] as the country of origin. We were able to trace three N. Wallich specimens deposited at BR, K and SING. Among these, we have selected the Kew specimen (barcode K000592582) as the lectotype of *C. diaphanus* (Fig. 6).

We examined specimens from China, India (Uttarakhand, Sikkim) and Nepal, which show considerable variation in plant height, spikelet shape, size and glume colour. Plant height ranges from 2 to 32 cm. Spikelet shape varies from ovate (7.6–9 × 3.2–3.5 mm) to ovate-lanceolate (8–17 × 3–3.5 mm) and glumes are either reddish-brown or pale brown. Additionally, nutlet range in colour from brownish to blackish, and possesses a broadly obovoid, biconvex or turgid shape. They display distinct waxy undulations on their surfaces, with epidermal cells longitudinally stretched (Fig. 2G, 2H).

A study on the type of *Pycnus pseudolatespicatus* L.K. Dai (K.K. Tsoong 8416) from Sichuan, China (Fig. 8) (Tang & Wang 1961), revealed that the taxon is indeed a part of *Cyperus diaphanus* Schrad. ex Schult. The type specimen of *P. pseudolatespicatus*, is relatively immature, with its nutlets not having reached full maturity. Nevertheless, even in this premature state, the broader spikelets, reddish-brown glumes, and transverse striation in nutlets are clearly visible (Fig. 2H).

Kükenthal (1913) treated plants with slender culms, reaching heights of 20–30 cm, thin leaves, and spikelets measuring 2–3 mm in width, as *Cyperus latespicatus* var. *gracilescens*. However, such slender forms with the specified spikelet width do not warrant a distinct taxon; rather, these characteristics represent variations within *C. diaphanus*. Although we were unable to locate the type of *C. latespicatus* var. *gracilescens* (Meebold no. 9353), we examined a Chinese specimen (F.T. Wang 23622b), mentioned by Kükenthal (1936) in the description of *C. latespicatus* var. *gracilescens*. The Chinese material appears to be of poor quality and is a slender form of *C. diaphanus*. All the specified characters, including plant height (approximately 25 cm long), ovate-lanceolate spikelets (4.8–9.1 × 2.1–3.6 mm), reddish-brown glumes, broadly obovoid nutlet (1 × 0.9–1 mm) displaying transverse striations with longitudinally stretched epidermal cells, align with those of *C. diaphanus*.

**Specimens examined:**—U GANGA & INDUS. Uttarakhand, Kumaon, *Strachey & Winterbottom* 3455 (DD). W NEPAL. Karnali, Mugu, Rara Lake, *A. Sukhorukov* 88 (BR [BR0000015218988V], MW [MW 0 734 066]). C NEPAL. Gandaki, Myagdi, Muri-Boghara, *M. Mikage et al.* 9682239 (KATH, TI); Kaski, Pokhara, *J.D.A. Stainton et al.* 7114 (BM [BM013399729]); Bagmati, Kathmandu, Lele, *K.R. Rajbhandari et al.* 75/880 (KATH); Bagmati, Rasuwa, Khanjim, *N.P. Manandhar et al.* 429 (KATH); Bagmati, Ramechhap, Jiri to Shivalaya, *M. Suzuki et al.* 8571669 (KATH [KATH030000]). E NEPAL. Koshi, Taplejung, Tamur River, near Chhiruwa, *C. Grey-Wilson et al.* 187 (KATH, L [L.3781803, L.3781804]). SIKKIM. Rongbe Ghora, *G.H. Cave s.n.* (THIM [THIM10722]). S HENGDUAN. Yulong, *R.-C. Ching* 21862 (PE); Binchuan, *T.N. Liou* 22186 (PE); Dali, *T.-N. Liou* 21016 (PE).

*Cyperus flavescens* Linnaeus (1753: 46) = *Chlorocyperus flavescens* (L.) Rikli (1895: 563) = *Distimus flavescens* (L.) Rafinesque (1819: 105) = *Pycnus flavescens* (L.) P.Beauv. ex Reichenbach (1830: 72). Lectotype (designated by Kukkonen in Cafferty & Jarvis 2004):—“In Germaniae, Helvetiae, Galliae, paludosis” Herb. Burser I: 81 (UPS!).

Annual herbs. Culm tufted, 10 cm long, 1 mm wide, 3-angled. Leaves equal to or shorter than culm, 1–1.2 mm wide. Involucral bracts 2 or 3, leaflike, to 3 cm long. Inflorescence a simple anthela with 1 or 2 rays, rays up to 3 cm long. Spikelets compressed, linear-oblong, 5–12.6 × 1.6–2.2 mm, bearing 10 to 26 flowers. Rachilla 4-sided, straight, wingless. Glumes semi-laxly imbricate, ovate, 1.5–2 × 0.6–0.9 mm, yellowish brown, veins 3, greenish, apex acute, margin narrowly hyaline. Nutlet narrowly obovoid, 1–1.1 × 0.6–0.7 mm, shiny-brownish, biconvex, faintly

transversely striate with longitudinally stretched epidermal cells, apex mucronate. Style slender, 0.6–0.8 mm long, stigmas 2, 0.4–0.5 mm long. Stamens 3, anther linear-oblong, 0.4 mm long. (Fig. 2J, 2K, 2L)

**Phenology:**—Flowering and fruiting from August to October.

**Habitats:**—Paddy fields; 1700 m.

**Distribution:**—Pan-Himalaya (Jammu & Kashmir), Iran, Kazakhstan, Lebanon, Turkey, Uzbekistan, Tajikistan; C Europe, Russia and Africa.

**Specimens examined:**—**JAMMU & KASHMIR.** *T.N. Liou L. 5820* (PE).

***Cyperus flavidus*** Retz. (1788: 13) = *Pycneus flavidus* (Retz.) T. Koyama (1976: 316). Lectotype (designated by Fischer 1932):—INDIA, *J.G. König s.n.* (LD [LD1292087!]).

= *Cyperus globosus* var. *strictus* C.B. Clarke in Baker (1883: 280) = *Pycneus flavidus* var. *strictus* (C.B. Clarke) Karthikeyan *et al.* (1989: 65) = *Pycneus globosus* var. *strictus* (C.B. Clarke) C.B. Clarke (1898: 15). Type:—Bourbon, Balfour (not located).

= *Cyperus nilagiricus* Hochst. ex Steudel (1854: 2) = *Cyperus globosus* var. *nilagiricus* (Hochst. ex Steud.) C.B. Clarke (1884: 49) = *Pycneus flavidus* var. *nilagiricus* (Hochst. ex Steud.) Karthikeyan *et al.* (1989: 65) = *Pycneus globosus* var. *nilagiricus* (Hochst. ex Steud.) C.B. Clarke (1898: 15). Type:—INDIA, Monts Nilagiri, 1851, *F. Metz 945* (BM [BM000959032!], P [P00585560!]).

= *Pycneus globosus* f. *khasianus* C.B. Clarke (1884: 48) = *Cyperus flavidus* var. *khasianus* (C.B. Clarke) Korlahalli (1967: 237) = *Cyperus globosus* var. *khasianus* (C.B. Clarke) Kükenthal (1936: 354) = *Pycneus flavidus* var. *khasianus* (C.B. Clarke) Karthikeyan *et al.* (1989: 65). Type:—Griffith, h. 6191 (P [P00585556!]).

= *Cyperus flavidus* var. *erectus* (C.B. Clarke) Korlahalli (1967: 237) = *Cyperus globosus* var. *erectus* (C.B. Clarke) Kükenthal (1936: 356) = *Pycneus flavidus* var. *erectus* (C.B. Clarke) Karthikeyan *et al.* (1989: 65) = *Pycneus globosus* var. *erectus* C.B. Clarke (1898: 15). Type:—Coromandelia, Koenig, Roxburgh (not located).

Annual or perennial herbs. Culm loosely to tightly tufted, sometimes well-spaced, 10–60 cm long. Leaves equal or shorter than the culm. Involucral bracts 2 or 3, leaflike, to 18(–40) cm long. Inflorescence terminal in simple anthela. Rays 2 to 6, 3–3.4 cm long, bearing 6 to 36 spikelets. Spikelets linear-oblong, spreading 7–15.8 × 1.7–2.3 cm, bearing 20 to 40 flowers. Rachilla 4-sided, straight, wingless. Glumes tightly to semi-laxly imbricate, ovate, 1.8–2.2 × 0.8–1 mm, dull brown to dark reddish, 3-veined, keeled, brown-reddish tinged, margin narrowly hyaline, apex obtuse. Nutlet narrowly obovoid, 0.8–1 × 0.5–0.6 mm, reddish brown, biconvex, densely punctulate with hexagonal cells, apex apiculate. Style slender, 0.5–0.7 mm long, stigmas 2, 0.6–0.8 mm long. Stamens 2, anther linear-oblong, 0.6 mm long. (Fig. 3A, 3B, 3C)

**Phenology:**—Flowering and fruiting from April to December.

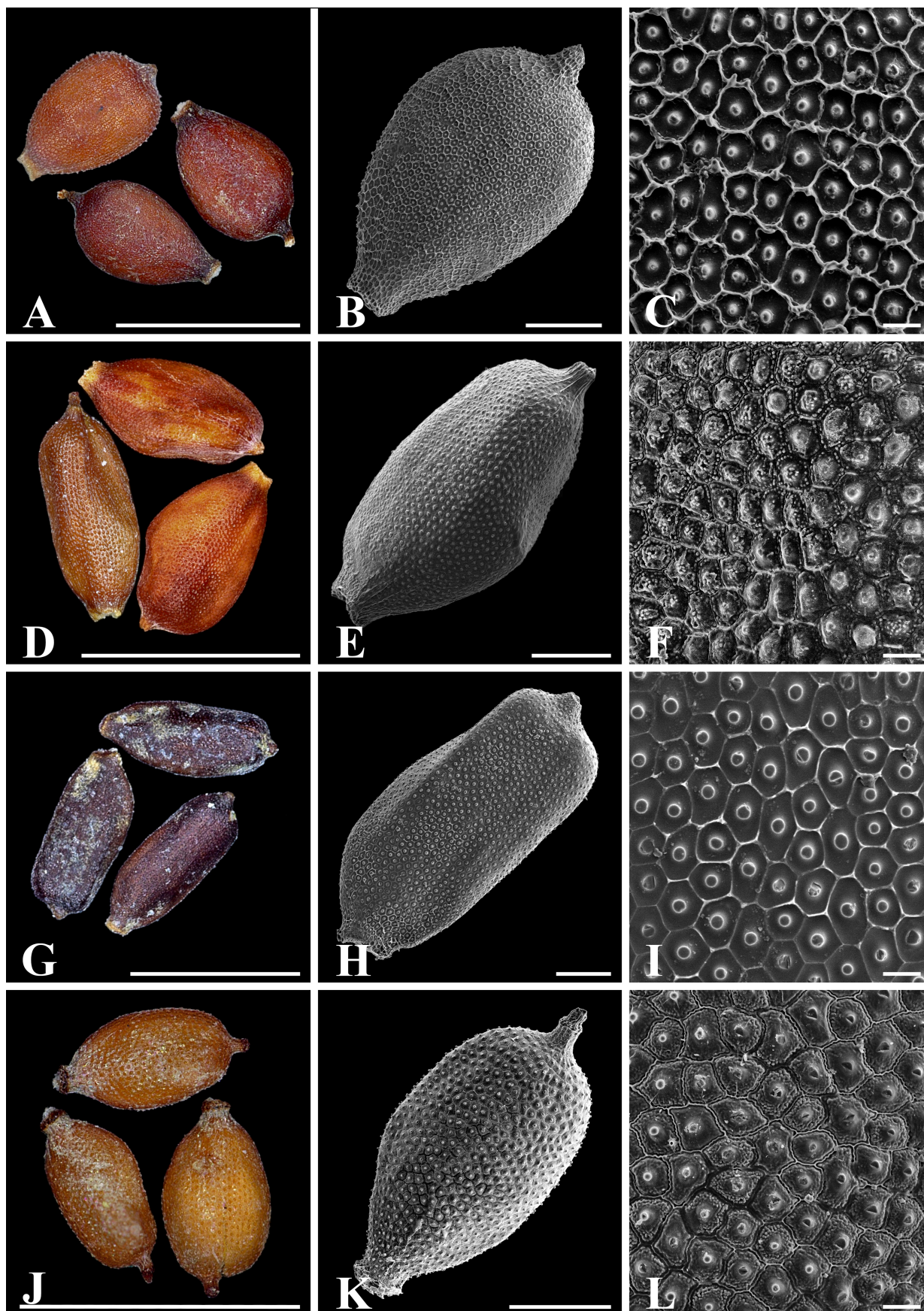
**Habitats:**—A common weed of paddy fields, often colonized the river banks, lake banks, stream banks, and water channels; 60–2900 m.

**Distribution:**—Pan-Himalaya (N Pakistan, Jammu & Kashmir, U Ganga & Indus, U Yarlung Zangbo, W Nepal, C Nepal, E Nepal, Bhutan, Yarlung Zangbo-Brahmaputra, S Hengduan), throughout Tropical Asia, Europe, and Africa to Australia.

**Notes:**—*Cyperus flavidus* is yet another species marked by considerable variability in its general morphology. This taxon is associated with over fifty names, highlighting significant diversity in both spikelet colour and shape (POWO 2023, Prasad & Simpson 2013).

**Specimens examined:**—**N PAKISTAN.** Naltar Valley, *S.Z. Husain et al. HLMS 94.0416* (MA [MA-01-00786006, MA-01-00786549]). **JAMMU & KASHMIR.** Dal lake, *R.R. Stewart 3768b* (US [02226019]); Srinagar, *H.M. Heybroek 80* (L [L.1369698]); **U GANGA & INDUS.** Kumaon, *R. Strachey & J.E. Winterbottom 6* (BR [BR0000021902734]); Dehra Dun, *U. Singh 1* (IBSC [0648086]). **W NEPAL.** Sudur Pashchim, Bajura, Angapani, *H. Tabata et al. 2633* (KATH); Sudur Pashchim, Kanchanpur, Mahendranagar, *K.R. Rajbhandari et al. 5009* (KATH); Karnali, Jumla, Poyora, *O. Polunin et al. 335* (BM [BM013399701]); Karnali, Dailekh, *K.R. Rajbhandari & B. Roy 2804* (KATH). **C NEPAL.** Lumbini, Kapilvastu, Jagdispur lake, *S.R. et al. 10086* (KATH); Gandaki, Kaski, Pokhara, *J.D.A. Stainton et al. 7114* (BM [BM013399730]); Bagmati, Kathmandu, Taudaha, *B.F.C. Sennitt 71303* (KATH); Bagmati, Chitwan, Sauraha, *H. Tabata et al. 9754* (TI); Madhesh, Tarai, *A. Zimmermann 2133* (BM [BM013399699]). Madhesh, Dhanusha, Chisapani, *P.R. Shakya & K.R. Rajbhandari 3164* (KATH). **E NEPAL.** Koshi, Sankhuwasabha, Tumlingtar, *Y. Tateishi 770020* (TI); Koshi, Taplejung, Tamur Valley, Thababu Khola, *J.D.A. Stainton 1188* (BM [BM013399694]); Koshi, Ilam, Maimajhuwa, *N.B. Khatri et al. C074* (KATH); Koshi, Jhapa, between Charali and Kakadbhita, *A. Neupane AN113* (KATH); Koshi, Morang, Letang, *R. Ojha 07R* (KATH). **BHUTAN.** Chapcha, 116 km north of Phuntsholing, *C. Parker 1022* (THIM [THIM10725]); Thimphu, *J.R. Woes 7139* (THIM [THIM10723]). **YARLUNG ZANGBO-BRAHMAPUTRA.** Mêdog, *Eco-Chamber Plateau group 11542* (PE [01726488, 01726489, 01726490]); Mêdog,





**FIGURE 3.** Nutlet diversity in *Pycreus* species in the Pan-Himalaya (A, B, C *Cyperus flavidus*; D, E, F: *C. lijiangensis*; G, H, I: *C. polystachyos*; J, K, L: *C. pumilus*). [Scale bar: first column = 1 mm, second column = 200  $\mu$ m, third column = 20  $\mu$ m]

*G. Xinfen et al.* 7989 (CDBI [CDBI0188041]); Nyingchi, *Li Bosheng et al.* 6170 (PE [01726473, 01726474]). **S HENGDUAN**. Liangshan, Meigu, *Vegetation group* 13024 (PE [01726511]); Garze, Daocheng, *Qinghai-Tibet Team Henguan Shan Team* 4242 (PE [01191246, 01191247]); Panzhihua, *M. Xian et al.* 452 (PE [01780423]); Shangri-la, *Beijing Hengduan Mountain Team* 02747 (PE [01447888, 01447889]); Lijiang, Ninglang, *T. Su et al.* ZK11441 (KUN [1399103]).

***Cyperus lijiangensis*** (Dai) P. Bhandari, B.Z. Li, & S.R. Zhang, *comb. nov.*  $\equiv$  *Pycneus lijiangensis* Dai in Tang & Wang (1961: 167, 233). Type:—CHINA, Yunnan, Lijiang (Likiang), 2000 m, June 1935, *C.W. Wang* 65044 (lectotype designated here: PE! (sheet number: 447350), isolectotype: PE!).

Annual herbs. Culm scattered, 14.5–24 cm high, 1–1.2 mm wide. Leaves shorter than culm, 4.5–12 cm long, 1.5–2 mm wide, apex acuminate. Involucral bracts 3, leaflike, longer than inflorescence, 2.4–7.5 cm long, 0.4–1.2 mm wide, margin scabrous. Inflorescence terminal, a simple anthela. Rays 1 or 2, very short, to 1.8 cm long. Spikelets clustered into a globose capitulum, spreading, ovoid, sub-elliptic to narrowly linear-ovoid, bearing 14 to 26 flowers, 4.7–9.5  $\times$  1.7–2.7 mm. Rachilla straight, wingless. Glumes tightly imbricate, ovate, 1–2.2  $\times$  0.5–0.8 mm, dark reddish, veins 3, margin and apex narrowly hyaline, apex acute. Nutlet obovoid-oblong, one side of apical surface slightly notched, 0.7–1.1  $\times$  0.4–0.6 mm, brownish, biconvex, densely punctate with hexagonal epidermal cells, apiculate. Style slender, 0.5–0.7 mm long, stigmas 2, 0.6–1 mm long. Stamens 2, filament 1.2–1.4 mm long, anther oblong, 0.4–0.5 mm long. (Fig. 3D, 3E, 3F)

**Phenology:**—Flowering and fruiting from June to July.

**Habitats:**—Wet places at river and pond banks; 2000 m.

**Distribution:**—Endemic (Pan-Himalaya: Yunnan, China).

**Notes:**—After reviewing the protologue and examining the type specimens of *Pycneus lijiangensis* Dai (*C.W. Wang* 65044) (Fig. 7), it becomes apparent that this taxon warrants a new combination and needs to be lectotypified. Consequently, we propose a new combination, *Cyperus lijiangensis*.

The two duplicates of *C.W. Wang* 65044 share the same collection label, and exhibit similar gross morphology. Both sheets contain an annotation slip reading '*Pycneus lijiangensis* L.K.Dai'; however, a proper type designation is lacking on both sheets. Following Art. 9.3 and 9.4 of the ICN (Turland *et al.* 2018), we designated sheet number 447350 as the lectotype of *P. lijiangensis*, as this sheet has a paper bag with some dissected materials, assuming the author examined this material while describing the species.

While *C. lijiangensis* shares morphological similarities with *C. flavidus*, it is distinguished by its very short inflorescence rays, which bear ovoid to narrowly linear-ovoid spikelets, along with narrowly obovoid-oblong nutlets. Furthermore, the surface of the nutlets in *C. lijiangensis* has a central silica body surrounded by granulated satellites, whereas such satellites are absent in *C. flavidus*.

***Cyperus polystachyos*** Rottbøll (1772: 21)  $\equiv$  *Pycneus polystachyos* (Rottb.) P. Beauvois (1816: 48). Lectotype (designated by Tucker 1983):—INDIA, *J.G. König s.n.* (C [C10010298 n.v.], isolectotype: C [C10010297!]); second-step lectotype (designated by Pereira-Silva *et al.* 2022).

Annual herbs. Culm tufted, 9–32 cm long, 1.2–1.3 mm wide, 3-angled, smooth. Leaves blade linear, flat, one-third the length of culm, 1.8–2.2 mm wide. Involucral bracts 3 to 5, leaflike, longer than inflorescence, 1.5–4.5 cm long. Inflorescence terminal, congested forming a capitate anthela. Spikelets sub-erect in very short rays, 5–8  $\times$  1.2–1.6 mm, linear-oblong, 8–22 flowered. Rachilla flexuose, narrowly winged. Glumes distichous, densely imbricate, ovate-oblong, 1.8–2  $\times$  1–1.2 mm, straw-coloured, keeled, 3-veined, apex minutely apiculate, margin hyaline. Nutlet narrowly oblong-obovoid, 0.8–1  $\times$  0.4–0.5 mm, maturing dark brown, biconvex, minutely punctate with hexagonal epidermal cells, apex rounded-truncate and mucronate. Style slender, 1–1.2 mm long, stigmas 2, 0.6 mm long. Stamens 2, anther linear, 1 mm long. (Fig. 3G, 3H, 3I)

**Phenology:**—Flowering and fruiting from September to October.

**Habitats:**—Grassy field, river banks; 100 m.

**Distribution:**—Pan-Himalaya (C Nepal, Bhutan), Tropics, Subtropics and Warm Temperate regions worldwide.

**Notes:**—*Cyperus polystachyos* is distinguished by its sub erect spikelets with a flexuose rachilla and linear-oblong nutlets.

**Specimen examined:**—C NEPAL. Bagmati, Chitwan, Chitwan National Park, *A. Kunwar et al.* CNP-52 (KATH, TUCH).



*Cyperus pumilus* Linnaeus (1756: 6)  $\equiv$  *Pycneus pumilus* (L.) Nees von Esenbeck (1834: 283). Lectotype (designated by Kukkonen in Cafferty & Jarvis 2004):—INDIA, collector unknown s.n., right specimen (LINN [Herb. Linn. no. 70.34!]).

= *Cyperus nitens* Retz (1788: 13)  $\equiv$  *Pycneus nitens* (Retz.) Nees von Esenbeck (1843: 53). Lectotype (designated by Fischer 1932):—INDIA, J.G. Koenig s.n. (LD!).

= *Cyperus patens* Vahl (1805: 334). Type:—Guinea Thonning. Simile e Java, nifallor, vidi (not located).

Annual herbs. Culm tufted, 3–10 cm long, 3-angled. Leaves shorter to longer than culm. Inflorescence a simple anthela, either forming rays or arranged in a globose capitulum bearing >20 spikelets. Involucral bracts 3, leaflike, exceeding inflorescence. Spikelets linear-oblong, 4–7  $\times$  1.5–2 mm. Rachilla straight, wingless. Glumes densely imbricate, ovate, 0.8–1.5  $\times$  0.6–1 mm, pale brownish, 3-veined, keeled, extending into a 0.3–0.4 mm mucro, apex emarginated, margin membranous. Nutlet oblong, oblong-obovoid or narrowly obovoid, 0.5–0.7  $\times$  0.4–0.5 mm, brownish, biconvex, densely punctate, truncate-apiculate. Style 0.3 mm long, stigmas 2. Stamens 2, anther oblong, 0.2 mm long. (Fig. 3J, 3K, 3L)

**Phenology:**—Flowering and fruiting from August to November.

**Habitats:**—On river beds, sandy soil and paddy fields; 80–2230 m.

**Distribution:**—Pan-Himalaya (U Ganga & Indus, W Nepal, C Nepal, E Nepal, Sikkim, Bhutan, S Hengduan), Tropical Asia, Africa and Australia.

**Specimens examined:**—U **GANGA & INDUS.** Uttarakhand, below Almora, 4000 ft, R. Strachey & J.E. Winterbottom 3 (BR [BR0000021904714]). **W NEPAL.** Sudur Paschim, Kanchanpur, Sukla Phant, I. Sharma et al. 248 (KATH); Sudur Pashchim, Bajhang, Badigaon – Talkot, M. Suzuki et al. 9193753-a (TI); Karnali, Rukum, Gija gaon, K.R. Rajbhandari & K.J. Malla 6547 (KATH); Lumbini, Banke, Nepalganj, S.A. Siddiqui 2201 (KATH). **C NEPAL.** Gandaki, Myagdi, between Jugepani to Dhola Khola, M. Mikage et al. 9682437 (KATH); Gandaki, Kaski, Pokhara Valley, P. Bhandari & V. Thapa 20120901 (KATH); Gandaki, Lamjung, Simalchour – Bhote odor, K.R. Rajbhandari 9248A (KATH); Bagmati, Sindhupalchok, Barabise – Thala, H. Kanai et al. s.n. (TI); Bagmati, Dhading, C. Grey-Wilson et al. 9 (KATH); Madhesh, Bara, near Simara, M. Timilsina MT05 (KATH). **E NEPAL.** Koshi, Morang, Palase – Bisnetan, T.B. Shrestha & T.K. Bhattacharya 72/209 (KATH). Koshi, Jhapa, Charali – Kakadbhita, A. Neupane ANJ106a (KATH). **SIKKIM.** North of Rungeet, C.B. Clarke 9757 (US [02229129]).

*Cyperus sanguinolentus* Vahl (1805: 351)  $\equiv$  *Pycneus sanguinolentus* (Vahl) Nees von Esenbeck (1836: 283), nom. cons. Neotype (designated by Kern 1954):—INDIA, Uttar Pradesh, Tehri-Garhwal, 3000 ft, October 1894, J.S. Gamble 15117 (L [L0042455!]).

= *Cyperus concolor* Steudel (1855: 6). Type:—INDIA, In montibus Nilagiri, 1851, Metz 946 (BM [BM000959036!], C [C10010323!], JE [JE00019477!], L [L0042454!], MPU [MPU028148!], P [P00852363!, P00852365!]).

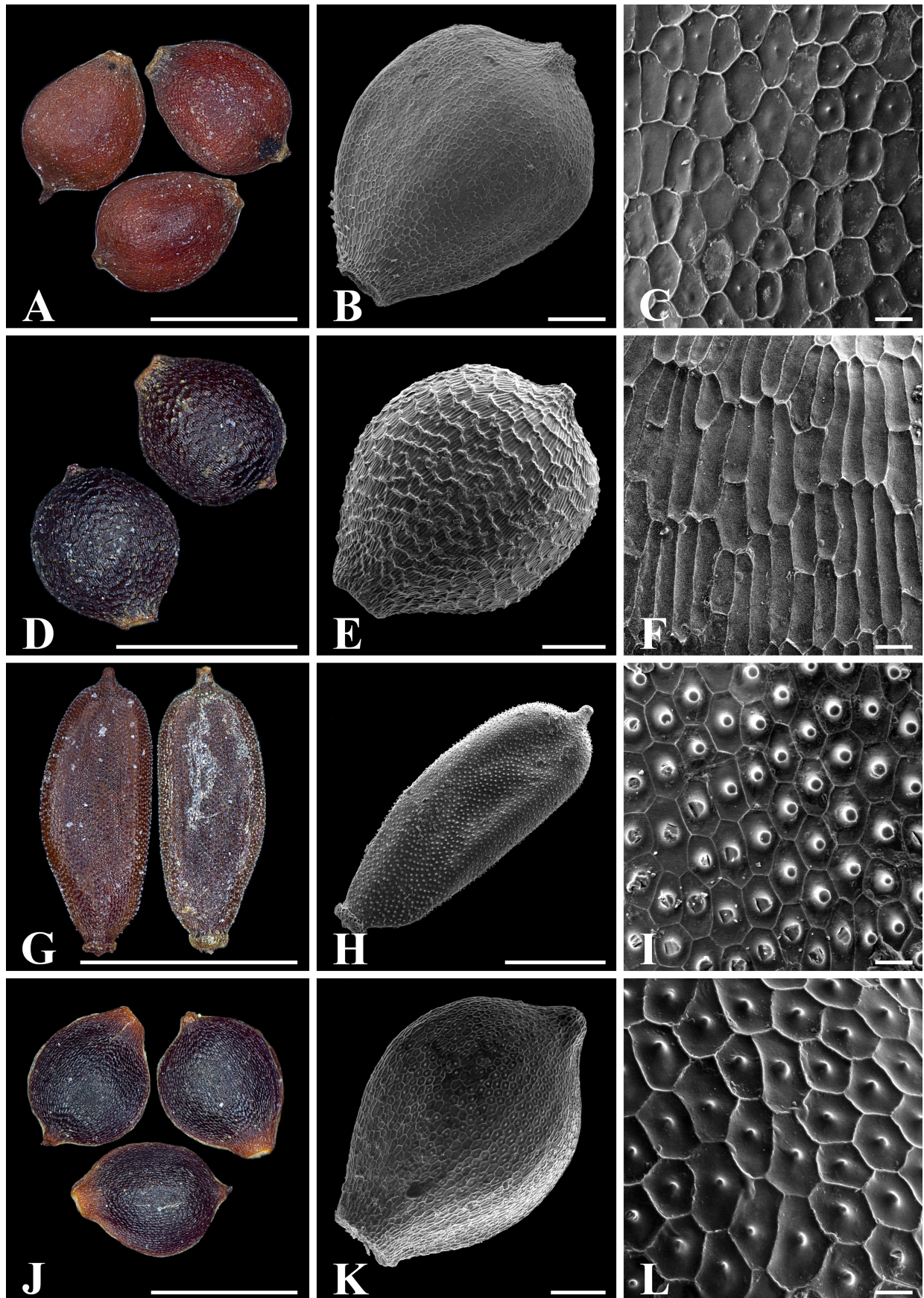
= *Cyperus cruentus* Retz (1788: 13). Lectotype (designated by Fischer 1932):—INDIA, J.G. König s.n. (LD [LD1291667!]).

= *Cyperus melanocephalus* Miquel (1855: 259)  $\equiv$  *Cyperus sanguinolentus* f. *melanocephalus* (Miq.) Kükenthal (1936: 387)  $\equiv$  *Cyperus sanguinolentus* subsp. *melanocephalus* (Miq.) J. Kern (1954: 55)  $\equiv$  *Pycneus sanguinolentus* f. *melanocephalus* (Miq.) L.K. Dai in Tang & Wang (1961: 172)  $\equiv$  *Pycneus sanguinolentus* subsp. *melanocephalus* (Miq.) Karthikeyan et al. (1989: 66). Type:—INDONESIA, Java, Dieng, in ulinosis planitici, 6200 ft, Junghuhn 537 (L [L0042451!]).

= *Cyperus eragrostis* var. *humilis* Miquel (1855: 257)  $\equiv$  *Cyperus sanguinolentus* f. *humilis* (Miq.) Kükenthal (1936: 386)  $\equiv$  *Pycneus sanguinolentus* f. *humilis* (Miq.) L.K. Dai in Tang & Wang (1961: 171). Type:—INDONESIA, Deing, Junghuhn 510 (L [L0042452!]).

= *Cyperus flavescens* var. *rubromarginatus* Schrenk ex Fischer & Meyer (1841: 3)  $\equiv$  *Cyperus sanguinolentus* f. *rubromarginatus* (Schrenk) Kükenthal (1936: 386)  $\equiv$  *Pycneus sanguinolentus* f. *rubromarginatus* (Schrenk) L.K. Dai in Tang & Wang (1961: 171). Type:—not located.

Annual herbs. Culm erect, loosely tufted, (0.7–)2–40 cm long, 0.5–2.1 mm wide, 3-angled, noded. Leaves shorter, equal to or exceeding the culm, 2–4.4 mm wide. Involucral bracts 1 to 4, leaflike, longer than inflorescence, 2.8–11.5 cm long, 1.1–3.4 mm wide. Inflorescence terminal in a simple anthela, producing 1 to 5 rays, sometimes forming a capitulum. Rays 3, 1.5–5 cm long, each bearing 3 to 10 spikelets. Spikelets compressed, radially spreading, lanceolate-oblong, 4.2–15  $\times$  1.7–2.8 mm, bearing 8 to 26 flowers. Rachilla straight, wingless. Glumes loosely or tightly imbricate, ovate, 1.5–2.2  $\times$  1–1.2 mm, purplish brown, furcate on each side of midvein, veins 3 to 5 producing a non-excurrent mucro, margin hyaline, apex acute. Nutlet obovoid-globose, half as subtending glumes, 0.8–1  $\times$  0.6–0.8 mm, brownish, biconvex, cancellate with isodiametric epidermal cells, apex apiculate. Style 1 mm long, stigmas 2, 1 mm long. Stamens 2 or 3, anther 1 mm long. (Fig. 4A, 4B, 4C)



**FIGURE 4.** Nutlet diversity in *Pycnus* species in the Pan-Himalaya (A, B, C *Cyperus sanguinolentus*; D, E, F: *C. substramineus*; G, H, I: *C. sulcinus*; J, K, L: *C. unioides*) [Scale bar: first column = 1 mm, second column = 200 µm, third column = 20 µm]





**FIGURE 5.** *Cyperus africanus* A. Habit B. Inflorescence C. Nutlet [P. Bhandari KAS21 (KATH)]

**Phenology:**—Flowering and fruiting all-round year.

**Habitats:**—A common weed in agricultural fields frequently grows in buggy and damp ground, river banks, lake banks and along water canals; 60–3962 m.

**Distribution:**—Pan-Himalaya (N Pakistan, Jammu & Kashmir, U Yarlung Zangbo, W Nepal, C Nepal, E Nepal, Sikkim, Bhutan, S Hengduan); Tropical to Temperate Asia, Africa and Australia.

**Notes:** *Cyperus sanguinolentus* is an exceptionally variable species with over thirty synonyms (Kern 1954, POWO 2023). This species shows extreme variation in the number of inflorescence rays, spikelet size, and stamens number. Nevertheless, the species is easily identifiable by the presence of nodes in the lower part of the culm and the presence of furrows on both sides of the glumes (Dai *et al.* 2010).

**Specimens examined:**—**N PAKISTAN.** Baltistan, Khapalu, *Anonymous* 5760 (K [K000592580]). **JAMMU & KASHMIR.** Muree Hills, *R.R. Stewart* 4003a (US [US 1174715]); Buniyar Valley, *H.M. Heybroek* 10a (L [L.1378019]); Himachal, Chamba, 6500 ft, *K. Walter* 8833 (US [02229443]). **U GANGA & INDUS.** Kumaon, *R. Blikworth* 3319G (K-W [K001119083]); Utrakhand, Dehradun, *S.K. Malhotra* 34863 (L [L.1378158]). **U YARLUNG ZANGBO.** Rikaze, Gyirong, *Li Bosheng et al.* 13523 (PE [01506986, 01506987, 01506988]). **W NEPAL.** Sudur Paschim, Bajura, Porakya pass, *H. Tabata et al.* 2622 (KATH [KATH030013]); Sudur Paschim, Kanchanpur, Royal Suklaphanta Wildlife Reserve, *M. Mikage et al.* 9689179 (BM [BM013399727], KATH); Sudur Paschim, Bajhang, between Talkot and Panalta, *H.N. Qin et al.* 138 (KATH, PE); Karnali, Jumla, Tarakot, *S. Einarsson et al.* 2372–2374 (BM [BM013399558]); Karnali, Kalikot, Nagma, *N.P. Manandhar & P. Joshi* 8247 (KATH). **C NEPAL.** Gandaki, Myagdi, Murigurja Gad, *J.D.A. Stainton et al.* 3655 (BM [BM013399710]); Gandaki, Kaski, Kaseri, *N.P. Manandhar* 11103 (KATH); Bagmati, Nuwakot, Samri Khola, *P.C. Gardner* 141 (BM [BM013399719]); Bagmati, Lalitpur, Phulchoki, 6500, *B.F.C. Sennitt* 71282 (KATH); Madhesh, Dhanusha, Chisapani, *P.R. Shakya & K.R. Rajbhandari* 3178 (KATH). **E NEPAL.** Koshi, Sankhuwasabha, Sedua, *J.D.A. Stainton* 485A (BM [BM013399714]); Koshi, Ilam, Dharapani, *J.F. Dobremez* 180 (TI); Koshi, Sunsari, Koshi Tappu Wildlife Reserve, *M. Mikage et al.* 9552927 (BM [BM013399721], KATH [KATH022045]); Koshi, Jhapa, between Charali and Kakadbhita, *A. Neupane ANJ107a* (KATH). **SIKKIM.** *C.B. Clarke s.n.* (L [L.1378026], US [02229319, 02229282]); Bulweschhar thal, 2000 ft, ex herb. *O. Kuntze* 6985 (US [02229322]); Sikkim, 5000–10000 ft, *J.D. Hooker s.n.* (BR [BR0000021904790], L [L.1377992]). **BHUTAN.** Gon Chungnang – Punakha, *H. Kanai et al.* 15066 (BM [BM013399723]); Mangde Chu Valley, South of Tongsa, *A.J.C. Grierson & D.G. Long* 2640a\* (THIM [THIM10727]); Punakha, Tang Chu (27 30 N, 89 58 E), *I.W.J. Sinclair & D.G. Long* 5607 (THIM [THIM10728]). **M YARLUNG ZANGBO.** Lhasa, *H. Li et al.* Q-09-70 (KUN [1399073, 1399074, 1399076]). **L YARLUNG ZANGBO.** Nyingchi, *L. Yang et al.* LJ755 (KUN [1399080]). **YARLUNG ZANGBO-BRAHMAPUTRA.** Mêdog, *S. Cheng et al.* 1446 (PE [01461029, 01461030, 01726558, 01726559]); Lhünzê, Zara Township, *PE-Xizang Expedition* PE5717 (PE [01891520, 01891521, 01891522]). **S HENGDUAN.** Dêqên, *D. Yu* 10314 (IBSC [0648309]); Nujiang, Gongshan, *G. Feng* 8027 (IBSC [0648308]); Panzhihua, Miyi, *Miyi Working Group* 238 (CDBI [CDBI0161797]); Liangshan, Muli, *Team Qinghai* 13522 (PE [01191250, 01191256]); Lijiang, Ninglang, *Qinghai-Tibet Grassland Group* 94(1) (PE [01191251]); Garze, Luding, 1800 m, *Vegetation group* 32084 (CDBI [CDBI0161794]); Lushui, *Dulongjiang expedition* 58 (KUN [0372715]); Liangshan, Mianning, *D. Zhang et al.* DC-07ZX02441 (KUN [1399105]). **U IRRAWADDY.** Tengchong, 2070 m, *Y. Zhou* YZ077 (KUN [1448839]).

*Cyperus substramineus* Kükenthal (1936: 398) ≡ *Pycneus substramineus* (Kük.) N.K. Khoi (1981: 140) ≡ *Cyperus stramineus* Nees von Esenbeck (1834: 74) ≡ *Pycneus stramineus* C.B. Clarke (1893: 589). Type:—BANGLADESH, Sillet [Sylhet], *N. Wallich Cat. no. 3320B* (lectotype designated here: CGE [CGE00055922!], isolectotypes: CGE [CGE00055923!], K-W [K001119087!], K000881560!, BR [BR0000006595890!], L [L 0042476!], P [P00585553!], NY [NY00011804!]).

Annual herbs. Culm slender, tufted, 10–22 cm long, 0.6–0.7 mm wide, 3-angled. Leaves shorter than the culm, canaliculate. Involucral bracts 1 to 3, leaflike, longer than inflorescence, to 10 cm long, 0.7–1 mm wide. Inflorescence simple, spicate, bearing 2 to 10 spikelets. Spikelets sub erect, linear-oblong, flattened, 4.5–18 × 0.8–2.4 mm, bearing 10 to 30 flowers. Rachilla straight, wingless. Glumes tightly imbricate, ovate, 2–2.4 × 1.4–2 mm, stramineous-yellowish, veins 3, reddish-tinged, middle vein slightly keeled and apiculate, apex acute, margin broadly hyaline. Nutlet obovoid-elliptic, 0.9–1 × 0.7–0.8 mm, blackish, biconvex, transversely wavy wrinkled, apiculate. Style 1.5 mm long, stigmas 2, 0.8 mm long. Anther 0.5 mm long. (Fig. 4D, 4E, 4F)

**Phenology:**—Flowering and fruiting from August to December.

**Habitats:**—Grows near water bodies, roadsides, and paddy fields; 100–300 m.





**FIGURE 6.** Lectotype of *Cyperus diaphanus* Schrader ex Schultes (N. Wallich s.n. [K, K000592582], © RBG Kew, the image of the lectotype is available at <http://specimens.kew.org/herbarium/K000592582>)



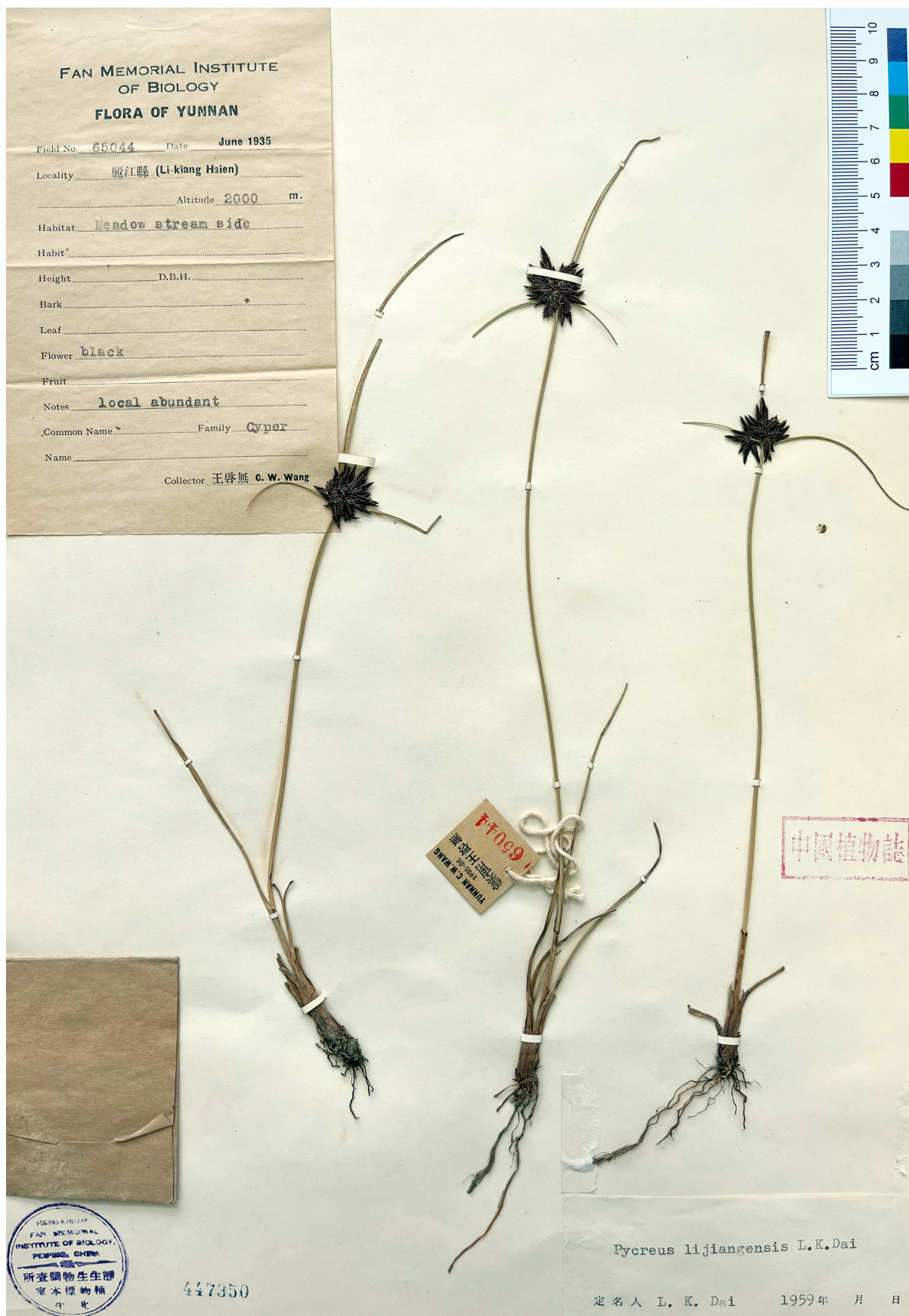


FIGURE 7. Lectotype of *Pycnus lijiangensis* Dai [C.W. Wang 65044 (PE), sheet 447350]

**Distribution:**—Pan-Himalaya (E Nepal, Bhutan), Bangladesh, Myanmar, Malaysia, Thailand and Vietnam.

**Notes:**—Nees von Esenbeck (1834) described *Cyperus stramineus* based on Wallich Cat. No. 3320B, collected by F. De Silva from Sillet (now Sylhet). Nees's original materials, stored at B, were unfortunately destroyed during World War II (Stafleu & Cowan 1985). However, several Nees's Cyperaceae specimens are housed at the Lindley herbarium (CGE), and we have designated CGE00055923 as the lectotype for *Cyperus substramineus* (Fig. 9). All other specimens, including Wallich Cat. No. 3320B, deposited at Br, CGE, K-W, L, NY, are considered isolectotypes.

*Cyperus substramineus* can be distinguished from its allies by its distinctive stramineous glumes, which exhibit a yellowish colour. The inflorescence is simple, spikelets arranged in very short rays, and the nutlet appears transversely wrinkled resulting from the longitudinally stretching of epidermal cells.

**Specimens examined:**—**E NEPAL.** Koshi, Jhapa, between Charali and Kakadbhita, *A. Neupane ANJ106* (KATH). **BHUTAN.** Gaylegphug, *J.R.I. Wood 6833* (THIM [THIM16090]).

***Cyperus sulcinux*** C.B. Clarke (1884: 56)  $\equiv$  *Pycneus sulcinux* (C.B. Clarke) C.B. Clarke (1893: 593). Type:—INDIA, Sikkim, Little Runjeet, 02 October 1875, *C.B. Clarke 24860* (lectotype designated here: K [K000592575!]). BANGLADESH, Shoosnury, Mymensingh, 12 July 1872, *C.B. Clarke 17295A* (syntype: K [K000592576!]). PHILIPPINES, Camiguin Island, January 1875, *H.N. Moseley s.n.* (syntype: K [K000290922!]). INDIA, Darjeeling, 23 August 1875, *C.B. Clarke 27156A* (syntype: BM [BM000959034!]). INDIA, Madras austr. Anamallays, 3000 ft, *R.H. Beddome s.n.*, p.p. (syntype: BM [BM000959035!]).

Annual herbs. Culm loosely tufted, 10–22 cm long. Leaves shorter than the culm. Involucral bracts 2 to 3, leaflike, shorter or equal to the inflorescence. Inflorescence terminal in simple anthela, with 1 or 2 rays. Rays to 6.5 cm long. Spikelet spreading, linear-lanceolate, 6–20  $\times$  1–1.8 mm, strongly flattened, 8 to 24 flowered. Rachilla flexuose, narrowly winged. Glumes loosely imbricate, oblong-ovoid, 1.5–2  $\times$  1 mm, yellowish brown, veins 3, keeled, apex obtuse, margin broadly hyaline. Nutlet oblong, 1.2–1.4  $\times$  0.5–0.6 mm, reddish brown, lenticular, shallow median longitudinal depression on each side, densely punctate, mucronate. Style 0.6 mm long, stigmas 2, 0.3 mm long. Stamen 1, 1.5 mm long, anther oblong, 0.3 mm long. (Fig. 4G, 4H, 4I)

**Phenology:**—Flowering and fruiting from June to August.

**Habitats:**—Lake banks, river banks, open land, and weedy herb of a maize field; 175–1500 m.

**Distribution:**—Pan-Himalaya (U Yarlung Zangbo, C Nepal, Sikkim, Bhutan), Myanmar, Bangladesh, Cambodia, Indonesia, Philippines, Thailand, Vietnam and Australia.

**Notes:**—Clarke (1884) described *Cyperus sulcinux* citing multiple specimens collected from Bangladesh, India and the Philippines. Of these, K000592575 is selected here as the lectotype (Fig. 10). The well-preserved sample and handwritten label by Clarke on the specimen support the selection of this specimen as the lectotype.

*Cyperus sulcinux* is rather rare in the Pan-Himalaya. The spikelets are spreading and measure between 6–20 mm in length. The glumes are obtuse and the stamen is consistently single in number. Additionally, the nutlets of *C. sulcinux* have shallow median longitudinal depression on both faces (Kern 1954).

**Specimens examined:**—**C NEPAL.** Gandaki, Kaski, Bindabasini, *N.P. Manandhar & L.P. Katel 10839* (KATH); Gandaki, Kaski, Neureni Lake, *P. Bhandari & N.L. Bhandari 20123004* (KATH); Bagmati, Dolakha, 950 m, *K.R. Rajbhandari & B. Roy 1263* (KATH); Bagmati, Dolakha, Malepu, *K.R. Rajbhandari 9321* (KATH). **BHUTAN.** Phontholing, *H.J. Noltie 2* (MO). **YARLUNG ZANGBO-BRAHMAPUTRA.** Mêdog, *Tibet Expedition of the Institute of Biology 1449* (HNWP).

***Cyperus uniolooides*** R. Brown (1810: 216)  $\equiv$  *Pycneus uniolooides* (R. Br.) Urban (1900: 164). Lectotype (designated by Tucker 1983):—AUSTRALIA, Queensland, Shoalwater Bay, August – September 1802–1805, *R. Brown 5900* (K [K000881559!], isolectotype: BM [BM000990841!]; second-step lectotype (designated by Pereira-Silva *et al.* 2022).

= *Cyperus angulatus* Nees von Esenbeck (1834: 73)  $\equiv$  *Pycneus angulatus* (Nees) Nees ex C.B. Clarke (1893: 593). Type:—NEPAL, Bagmati, *N. Wallich 3324A* (lectotype designated here: K-W [K000592569!], isolectotypes: BM [BM013399681!, BM013399682!, BM013399683!], BR [BR0000021904974!], K-W [K001119095!, K000592570!], P [P00585567!]). MYANAMR, Ava, *N. Wallich 3324B* (syntypes: K-W [K001119096!], NY [NY00011795!]).

= *Pycneus chekiangensis* Tang & Wang (1961: 165, 232). Type:—CHINA, Zhejiang, 19 September 1932, *S. Chen 758* (holotype: PE [PE01842098!], isotype: PE [PE01842099!]).





FIGURE 8. Holotype of *Pycnus pseudolatespicatus* Dai [8846 (PE)]





FIGURE 9. Lectotype of *Cyperus substramineus* Kükenthal (N. Wallich 3320B (CGE [CGE, CGE00055922!]))





**FIGURE 10.** Lectotype of *Cyperus sulcinus* C.B. Clarke (C.B. Clarke 24860 [K, K000592575], © RBG Kew, the image of the lectotype is available at <http://specimens.kew.org/herbarium/K000592575>)



Rhizomatous, perennial herbs. Culm loosely tufted, 17–70 cm, 1.2–1.3 mm wide, 3-angled, smooth. Leaves shorter or longer than culm. Involucral bracts 2 to 4, leaflike, much longer than inflorescence, to 18 cm long. Inflorescence terminal in simple anthela, spikelets laxly arranged in well-developed rays, rays 1 to 4, 1.5–6 cm, each ray consisting of 4 to 9 spikelets. Spikelet spreading, compressed, oblong-ovoid to narrowly ovoid, 7–18.8 × 2.7–5 mm, pale yellow. Rachilla slightly flexuose, wingless. Glumes tightly imbricate, ovate-broadly ovate, 2.5–4.3 × 2–2.9 mm, straw-coloured, glabrous, leathery, 3-veined, apex acute. Nutlet globose-obovoid to broadly obovoid, 1–1.3 × 0.7–1 mm, blackish, biconvex, punctate with hexagonal cells. Style slender, 2.5–3 mm long, stigmas 2, as long as style. Stamens 3, 3 mm long, anther linear, 2 mm long. (Fig. 4J, 4K, 4L)

**Phenology:**—Flowering and fruiting from July to September.

**Habitats:**—Grows near streamlets, moist downhill; 685–1900 m.

**Distribution:**—Pan-Himalaya (C Nepal, E Nepal, Bhutan, Yunnan); also in Zhejiang (China), Myanmar, Bangladesh, Thailand, Indonesia, Vietnam, Africa, Australia, North America and South America.

**Note:**—The well-preserved samples, the attached N. Wallich label, and the Clarke annotation support the selection of K000592569 as the lectotype of *Cyperus angulatus*.

**Specimens examined:**—C NEPAL. Gandaki, Kaski, Pokhara Valley, *P. Bhandari & M. Bhandari 21072803* (KATH); Bagmati, Dolakha, Jiri, *K.R. Rajbhandari & B. Roy 2112* (KATH). E NEPAL. Koshi, Taplejung, Sangrati Pati-Duwa Doban, *H. Ohashi, H. Kanai et al. 771148* (TI). S HENGDUAN. Lijiang, *Y. Pinghua 180* (IBSC [0648382]).

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