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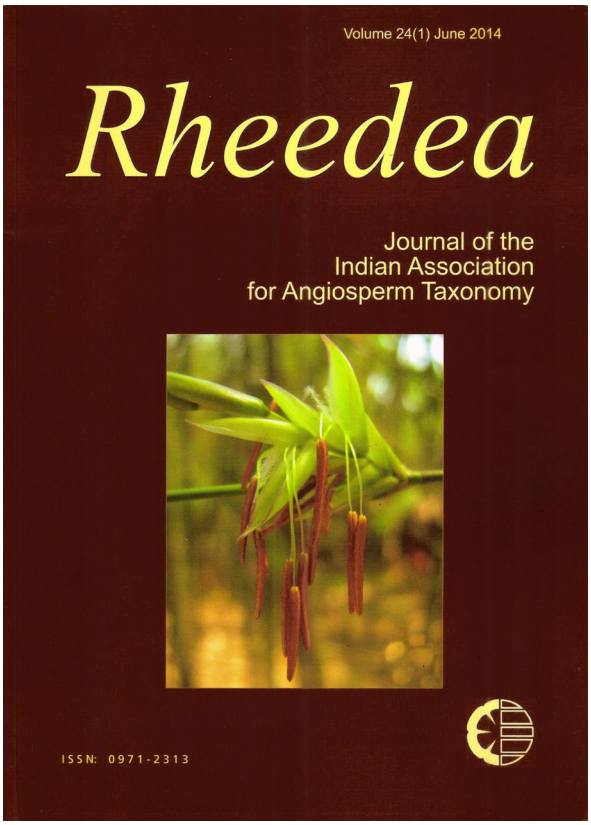

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Recent flowering of six species of bamboos (Poaceae: Bambusoideae) in northeastern India with identification keys

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Abstract

Six species of bamboos (Poaceae: Bambusoideae) have been found in flowering stage during 2010–2013 in northeastern India particularly in Assam and Tripura. Keys to species based on vegetative and reproductive characters of recently collected specimens are provided to facilitate easy identification. All species are provided with an updated nomenclature, description, illustration, photographs, vernacular names, phenology, habitat, distribution and specimens examined.

Keywords: Assam, Bamboo, Bambusoideae, Barak Valley, flowering, keys, northeastern India, Tripura

Introduction

Bamboo flowering is one of the mysterious phenomena in the plant world owing to its semelparous nature. Flowerings are of two types: gregarious and sporadic. In the gregarious type, flowering occurs over a large area and the clumps die off following flowering with or without seed setting. On the other hand, sporadic flowering generally occurs in a single clump or in a small group of clumps over an isolated area. The flowering cycle may vary from 20–60 years, sometimes even 120 years (McClure, 1966). Due to their rare, irregular and long interval flowering nature, bamboos have been identified and classified in most of the literature mainly on the basis of their vegetative characters. Although the culm sheath plays a significant role in the identification (Chatterji & Raizada, 1963; Sarma & Pathak, 2004) at species level, sometimes it is very difficult to distinguish them due to their variation in pubescence, shape, size and texture. Even within the same clump of a plant the culm sheaths may vary. In some cases, it is very difficult to differentiate between taxa only on the basis of their vegetative characters. Moreover, variation in vegetative characters due to ecological influences cannot be considered as stable features in the delimitation of taxa at specific and infraspecific level. Polyploidy is also a very common occurrence in Bambusoideae. Hence, identification of species based on both vegetative and reproductive characters is much reliable. Earlier, taxonomic treatment of different bamboos on the basis of their vegetative and reproductive characters had been attempted by different workers, *viz.* Munro (1868), Gamble (1896), Camus (1913) and Arber (1926, 1927, 1928).

The subfamily Bambusoideae comprises *c.* 91 genera and 1110 species (Clayton & Renvoize, 1986). In India, it is represented by *c.* 128 species under 18 genera (Seethalakshmi & Kumar, 1998). Northeastern India is one of bamboo rich areas of India where *c.* 80 species under 15 genera are contemplated (Shukla, 1996). Therefore, this paper is only a minor, but hopefully useful contribution.

While working on the floristics of the family Poaceae in Barak Valley region of Assam, the authors collected four species of bamboos in flowering stage during 2010–2013. These are *Bambusa cacharensis* R.B. Majumdar, *B. vulgaris* Schrad. ex J.C. Wendl., *Melocalamus compactiflorus* (Kurz) Benth. and *Schizostachyum dullooa* (Gamble) R.B. Majumdar. Additionally, two more species, *Bambusa nutans* Wall. ex Munro from the Brahmaputra Valley of Assam and *Dendrocalamus longispathus* (Kurz) Kurz from Tripura, have also been found in flowering condition recently.

Specimens were identified by critical morpho-taxonomic analysis, consultation of protologue, type and other authentic materials housed at

ASSAM and CAL. All six species are provided with an updated nomenclature, description, illustration, vernacular names, habitat, distribution and specimens examined. Illustrations have been made by the first author from the materials collected from the field. Vernacular names and distributional range have been gleaned from Barooah & Borthakur (2003), Koshy (2010), Naithani *et al.* (2010), Seethalakshmi & Kumar (1998), Tewari (1992) and the author's personal communication with the villagers during the field trip. A photographic plate for identification of species is also presented. Specimens are deposited in the herbarium of the Department of Life Science and Bioinformatics, Assam University, Silchar. Duplicates are deposited in ASSAM and CAL.

In this paper, a key on the basis of recently collected flowering materials from northeastern India is provided. A separate vegetative key is also provided.

Key to the species based on floral characters

1. Spikelets 15–75 mm long; lower glumes 4–15 mm long; glume and lemma acute-acuminate to mucronate at apex; rachilla well-developed; palea always shorter than the lemma; anthers 4–11 mm long; ovary 1.5–6 mm long 2
1. Spikelets 2.5–6 mm long; lower glumes 1.5–3.5 mm long; glume and lemma blunt-acute, sometimes with a minute mucro at apex; rachilla suppressed; palea as long as or longer than lemma; anthers 2–3.5 mm long; ovary 0.5–1 mm long 5

2. Fertile floret 1; rachilla glabrous throughout; palea nerve absent in between keels; lodicules 0; ovary glabrous ..... 6. **Schizostachyum dullooa**
2. Fertile florets 4–12; rachilla pubescent at least at mouth; palea 3–7 nerved in between keels; lodicules 3; ovary pubescent 3

3. Rachilla 2–3 mm long; lodicules 2–2.5 mm long; anthers 7–9 mm long; anther apiculate or penicillate at the tip 4
3. Rachilla *c.* 4 mm long; lodicules 5–8 mm long; anthers 4–5 mm long; anther tip emarginate, without any appendages, not apiculate or penicillate at the tip .... 1. **Bambusa cacharensis**

4. Rachilla pubescent throughout; lemma ciliate at upper half of the margin; palea ciliate throughout; palea 3-nerved in between keels, glabrous on adaxial surface; ovary *c.* 1.5 mm long, sessile ..... 3. **Bambusa vulgaris**
4. Rachilla glabrous except mouth; lemma serrate at upper half margin; palea ciliate at upper half margins; palea 3–5-nerved in between keels, pubescent on adaxial surface at apex; ovary 5–6 mm long, stalked ..... 2. **Bambusa nutans**

5. Glumes persistent on caryopsis; lodicules 3; ovary glabrous; stigmas 3; caryopsis sub-globose, large, 2–3.5 cm in diameter, fleshy .... 5. **Melocalamus compactiflorus**
5. Glumes not persistent on caryopsis; lodicules 0; ovary pubescent; stigma 1; caryopsis ovoid, minute, *c.* 2.6 × 2 mm, dry .... 4. **Dendrocalamus longispathus**

Key to the species based on vegetative characters

1. Imperfect blades more or less broadly triangular, erect; auricles of the culm sheaths usually large, 1–2 cm high, 1–7 cm broad at base 2
1. Imperfect blade narrowly triangular-lanceolate to subulate, recurved; auricles of the culm sheath usually small or absent, if present 0.3–0.4 × 0.8–1.2 cm 4

2. Sheath proper abaxially covered with chocolate-brown hairs; ligule margin entire; auricle 4–7 cm broad at base; secondary veins of leaves 4–5 pairs ..... 1. **Bambusa cacharensis**
2. Sheath proper abaxially covered with blackish-brown or black hairs; ligule margin dentate to dentulate; auricle 1–3 cm broad at base; secondary veins of leaves 6–11 pairs 3

3. Culms glossy, yellowish-green; sheath proper covered with blackish brown hairs; culm sheath ciliate at margin; both auricles erect; leaf sheath ciliate at margin ..... 3. **Bambusa vulgaris**
3. Culms somewhat dull, dark green; sheath proper covered with black hairs; culm sheath glabrous at margin; one of the auricles wavy downward, another erect; leaf sheath glabrous at margin . ..... 2. **Bambusa nutans**

4. Culms climbing; culm sheath persistent; sheath proper smooth with deciduous white pubescence on abaxial surface; auricle present .... 5. **Melocalamus compactiflorus**
4. Culms erect; culm sheath deciduous to sometimes persistent; sheath proper covered with whitish-golden or golden-brown appressed hairs on abaxial surface; auricle absent 5

5. Shrubs, 5–8 m high; sheath proper 7–13 cm long; sheath proper sparsely whitish-golden hairy on abaxial surface; ligule *c.* 1 mm long, entire ..... 6. **Schizostachyum dullooa**

5. Large trees, 8–20 m high; sheath proper 45–50 cm long; sheath proper densely golden-brown hairy on abaxial surface; ligule *c*. 3 mm long, fringed at margin ..... 4. **Dendrocalamus longispathus**

1. Bambusa cacharensis R.B. Majumdar, Bull. Bot. Surv. India 25: 237, t.3. 1983; S. Karthikeyan *et al*., Fl. Ind. Enumerat. - Monocot. 274. 1989; D.N. Tewari, Monogr. Bamboo 36. 1992; U. Shukla, Grasses N.E. India 181, t.40. 1996; K.K. Seethal. & M. Kumar, Bamboos India 49. t.9. 1998; Barooah & Borthakur, Diversity Distrib. Bamboos Assam 54, t.7. 2003; S. Chowdhury, Assam's Fl. 303. 2005; H.B. Naithani *et al*., Distrib. Bamboo Sp. Manipur 84. 2010. **Figs. 1, 7a-c**

Vernacular name: **Bengali –** *Betua, Betu bans.*

Type: INDIA, **Assam**, Cachar, Lockhipur, Mar Bastee, Lockhipur Steamer Ghat, Aug.-Sept., 1978, *Majumder* 74265 A (holo. CAL!).

Rhizomatous, caespitose, straight. Culms usually 8–21 m high, 4–10 m in diameter, green; internodes 35–64 cm long; mostly unbranched below. Culm sheaths deciduous; sheath proper 12–17 cm long, 26–32 cm broad at base, gradually attenuate upwards, rounded, 13–20 cm broad at mouth, densely covered with chocolate-brown, sharp, appressed, spicular hairs at abaxial surface, one margin ciliate; imperfect blade erect, triangular, 4–12 cm long, 13–20 cm broad at base, apex acuminate, densely covered with orange-yellowish, sharp hairs on abaxial surface, both margins long ciliate at base and shortly ciliate upwards. Ligule *c*. 3 mm high, entire. Auricles large, *c*. 2 cm high, 4–7 cm broad at base, wavy, erect, pubescent on outer surface, fringed with ciliate bristles. Leaf blades linear-lanceolate, 11–18 × 1.3–2 cm, equal and attenuate at base, acute-acuminate at apex; scabrous on ventral surface; midvein prominent to about half portion of leaves, secondary veins 4–5 pairs on either side of midvein, intermediate veins 9–10. Leaf sheaths glabrous, striate, entire at margins; ligule *c.* 0.5 mm long, entire. Auricles small with long bristles. Inflorescence branched panicles with cluster of spikelets. Spikelets 3.5–4 cm long, 6–12-flowered with terminal immature floret, glossy green. Glumes of same shape and texture, ovate, acuminate-mucronate; lower glume *c.* 6 × 3 mm; upper glume *c*. 7–9 × 3.5–4 mm. Rachilla *c.* 4 mm long, pubescent, ciliate at mouth. Lemma lanceolate-oblong, *c.* 13 × 6 mm, mucronate, 16–18 nerved, glabrous. Palea lanceolate-ovate, *c.* 12 × *c.* 4 mm, glabrous on both surfaces, smooth at margins, 2-keeled; ciliate at keels at upper half portion, 5–7-nerved in between keels and 3-nerved on either sides. Lodicules 3, oblong-obovate, 5–8 × 1–2 mm, hyaline, fimbriate at top. Stamens 6; anthers 4–5 × *c.* 1 mm, tip emarginated, without any appendage, glabrous. Ovary oblong-ovate, 2–5 × 1 mm, pubescent at upper half portion; style very short, pubescent; stigmas 3, plumose, 3–5 mm long. Caryopsis not seen.

Habitat: Found in open hilly slopes; cultivated in homegardens in the Barak Valley of Assam.

Specimens examined: INDIA, **Assam,** Barak Valley, Cachar dist, Dargakona, near Assam University Silchar Campus, 23.08.2010, *M. Devi & D. Bhattacharyya* 10603; Meherpur, 23.05.2011, *M. Devi & D. Bhattacharyya* 10690, 10691, 10692; Amraghat, on way to Bhuban hills, 20.02.2012, *M. Devi & D. Bhattacharyya* 10800; Dargakona, April, 2012, *M. Devi & D. Bhattacharyya* 10910, 10911, 10912, 10913, 10914, 10915; Karimganj dist, Patharkandi, Madhuban, 09.10.2011, *M. Devi & D. Bhattacharyya* 10765 (Herbarium Dept. Life Science & Bioinformatics, Assam University, Silchar).

Distribution: India (Assam, Manipur, Meghalaya, Tripura) and Bangladesh.

Flowering records: Majumder (1983) from Cachar district, Assam; Singha *et al.* (2003) from Southern part of Northeast India (exact locality not mentioned); Devi and Bhattacharyya (2013a) from Barak Valley of Assam; Debbarman *et al*. (2013) from Tripura (West).

2. Bambusa nutans Wall. ex Munro**,** Trans. Linn. Soc. 26 (1): 92. 1868; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 32, t.30. 1896, in Hook. f., Fl. Brit. India 7: 387, 1896; Brandis, Indian Trees 668. 1906; E.G. Camus, Bambusées 116, t.78B. 1913; Bor, Fl. Assam 5: 28. 1940; Deb, Fl. Tripura 2: 495. 1983; D.N. Tewari, Monogr. Bamboo 44. 1992; U. Shukla, Grasses N.E. India 183. t.50C. 1996; K.K. Seethal. & M. Kumar, Bamboos India 62, t.16. 1998; Barooah & Borthakur, Diversity Distrib. Bamboos Assam 63, t.11. 2003; S. Chowdhury, Assam's Fl. 304. 2005; H.B. Naithani *et al*., Distrib. Bamboo Sp. Manipur 91. 2010; K.C. Koshy, Bamboos TBGRI 34. 2010. **Figs. 2, 7d**

Vernacular names: **Assamese –** *Bidhuli, Deobans, Jatia mokal, Mukial*; **Bengali** – *Bakal, Makla*; **Bhutia** – *Jiu*; **Hindi** – *Malabans*; **Kangra** – *Nal*; **Khasi** – *Seringjai*; **Kuki** – *Wa-malang*; **Lepcha** – *Mahibans*, *Mahlu, Mallo*; **Orissa** – *Badia bansa*; **Tripura** – *Kali*; **Sylheti** –*Peechli*.

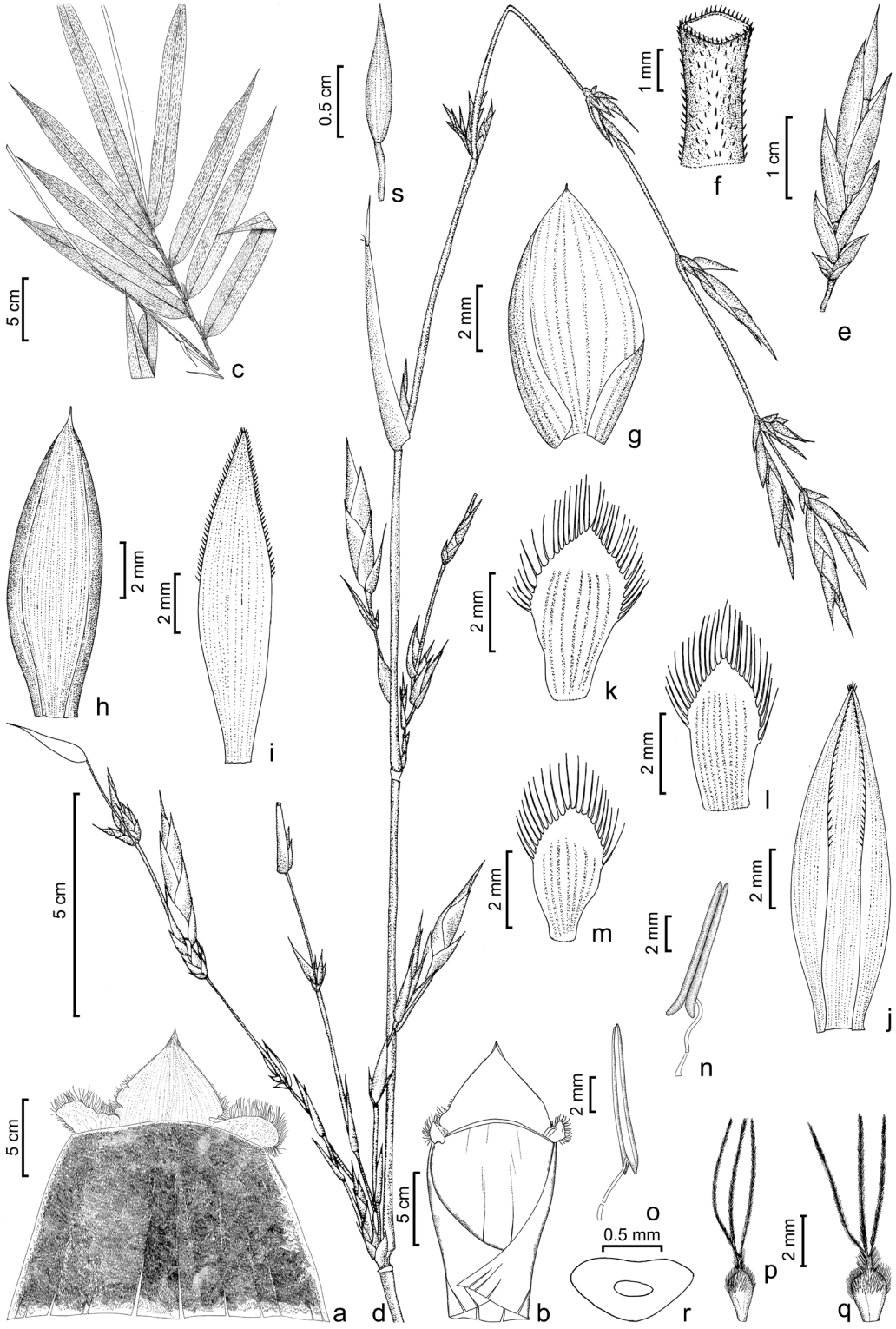

Fig. 1. *Bambusa cacharensis* R.B. Majumdar: **a.** Adaxial view of culm sheath; **b.** Abaxial view of culm sheath; **c.** Leaf twig; **d.** Inflorescence; **e.** Spikelet; **f.** Rachilla; **g.** Glume, **h.** Lemma; **i.** Adaxial view of palea; **j.** Abaxial view of palea; **k**, **l** & **m.** Lodicules; **n** & **o.** Stamens; **p** & **q.** Pistil; **r.** T.S. of ovary; **s.** Immature floret.

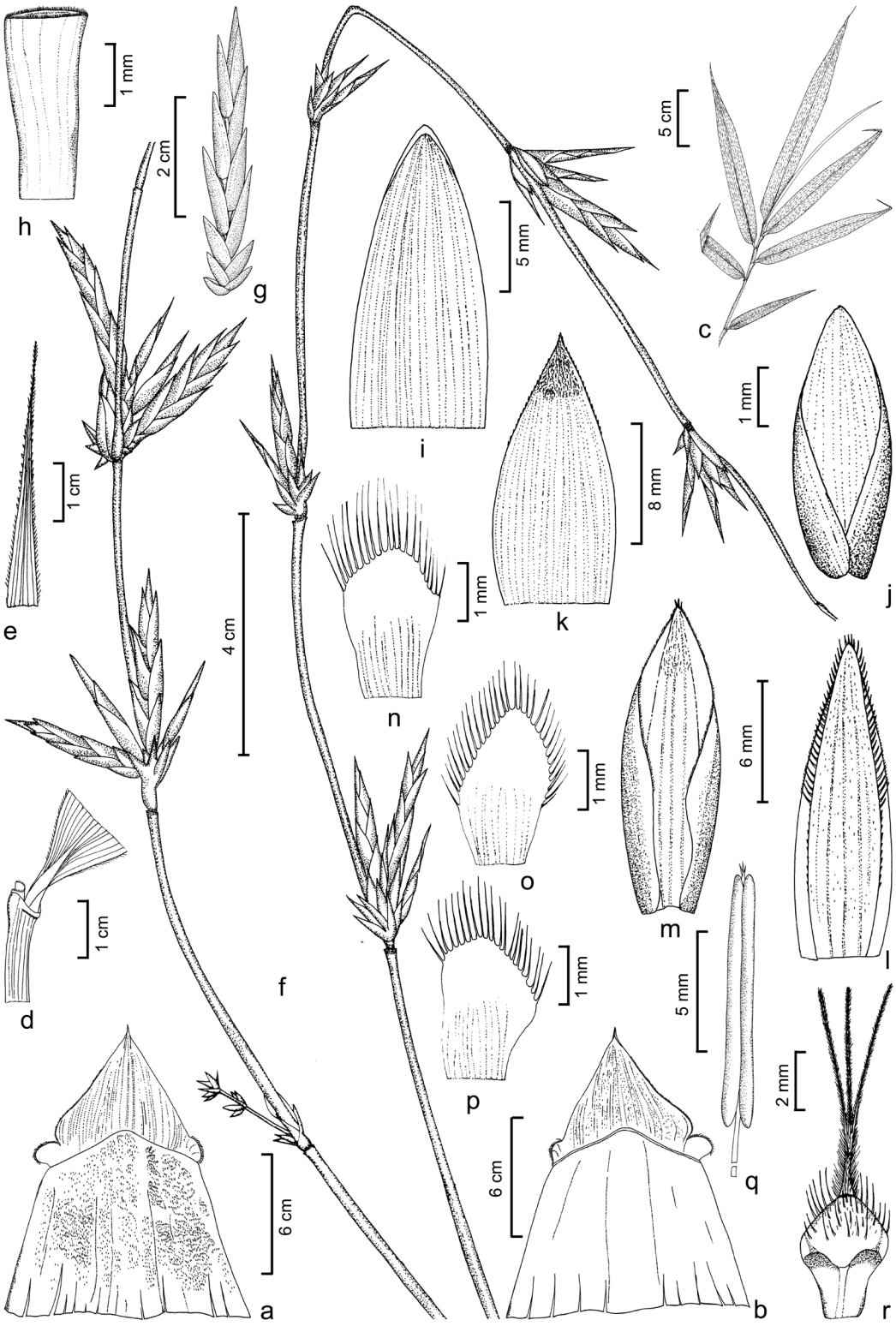

Fig. 2. *Bambusa nutans* Wall. ex Munro: **a.** Adaxial view of culm sheath; **b.** Abaxial view of culm sheath; **c.** Leaf twig; **d.** Leaf base & ligule; **e.** Leaf apex; **f.** Inflorescence; **g.** Spikelet; **h.** Rachilla; **i.** Bract; **j.** Glume; **k.** Lemma; **l.** Adaxial view of palea; **m.** Abaxial view of palea; **n**, **o** & **p.** Lodicules; **q.** Stamen; **r.** Pistil.

Type: NEPAL, **Kathmandu**, Naga-Arjun [Nagarjun, 27°44'N, 85°17'E], May 1821, *Wallich*, Cat. 5031 K–W IDC microfiche 7394 (isolecto. E, *n.v.*).

Rhizomatous, with creeping rootstalk, loosely clumped, moderate-sized. Culms 8–14 m high, 4–11 cm in diameter, dull, dark-green, smooth, white ring present below nodes; lower nodes with rootlets; internodes 20–40 cm long; branching above. Culm-sheaths shorter than the internodes, deciduous, triangular, yellowish-brown; sheath proper 12–17 cm long, 16–24 cm broad at base, attenuated to 8–14 cm wide mouth, convex at top with black hairs appressed on abaxial surface, smooth-shining and glabrous on adaxial surface, margins glabrous; imperfect blade persistent, erect, triangular, 4–14 cm long and 5–10 cm broad at base, continuing with auricles, terminating into pointed apex, striate, glabrous at abaxial surface, ciliate on adaxial surface, one margin ciliate from base to middle. Ligule *c*. 2 mm long, dentulate. Auricles unequal, dissimilar, one erect, somewhat sickle shaped, *c*. 20 × 12–20 mm; other rounded, continuing downward with the blade, *c*. 14 × 20 mm, glabrous on both surfaces with short stiff bristles at margins. Leaves 5–8 per twig. Leaf-blades lanceolate, 3–26 × 0.7–2.5 cm, base rounded-attenuate at base, apex acuminate; scabrous, pubescent on both surfaces, margins serrate; midvein prominent, glabrous; secondary veins 8–11 pairs on either side of midvein; tertiary veins 6–8; cross veins not prominent, pellucid glands present; pseudopetiole *c*. 3 mm long; leaf-sheath striate, glabrous, smooth at margins, ending into smooth, rounded callus. Ligule oblique, 1.5–2 mm long, truncate at top, glabrous, many-nerved, dentulate at mouth. Auricles erect, rounded at top, glabrous. Inflorescence a large radical leafless panicle. Spikelets cylindrical, 2–7.5 × 0.4–0.7 cm, mostly sessile, 6–9 fertile florets, glabrous, immature spikelet acute, mature spikelets composed of distinct florets with conspicuous rachilla. Bracts ovate-lanceolate, 1–4, 16–18 × *c.* 8 mm, acute at apex, 28–30-nerved, pubescent on abaxial surface, glabrous on adaxial surface, margins entire. Glumes 2–4, ovate, 4–9 mm long, acute at apex, 15–17-nerved, both surfaces glabrous. Rachilla clavate, *c.* 3 mm long, flattened, striate, glabrous except minutely ciliate at mouth. Lemma ovate, *c*. 16 × 7 mm, acute-acuminate to sub-mucronate at apex, 20–22-nerved, serrate on margins at upper half, glabrous on abaxial surface, pubescent on adaxial surface on upper top portion. Palea shorter than the lemma, boat-shaped, *c.* 13 mm long, acute at apex, penicillate at tip, minute scaberulous hairs on adaxial surface, 2-keeled; keels ciliate with long white hairs, 3–5-nerved between the keels, 2-nerved on either side; margins minutely ciliate on upper half. Lodicules 3, 2–2.5 mm long, hyaline, membranous, 5–10-nerved, fimbriate on upper portion; two oblong, obliquely truncate, thickened and fleshy below especially on one side; third one ovate, acute. Stamens 6, long, exserted; anthers 7–9 mm long, purple, glabrous, blunt at tip or emarginated; anther penicillate or apiculate at tip. Ovary sub-obovate, 5–6 mm long, stalked, white, pubescent above, glabrous below; style short, hairy, divided into 3 long plumose wavy stigmas. Caryopsis not seen.

Habitat: Common homegarden species in NE India; also found in the wild.

Specimen examined: INDIA, **Assam**, Brahmaputra Valley, Nagaon, Raha, way to Chaparmukh, 03.04.2011, *M. Devi* 11024, (Herbarium Dept. Life Science & Bioinformatics, Assam University, Silchar).

Distribution: India (Arunachal Pradesh, Assam, Bihar, Himachal Pradesh, Manipur, Madhya Pradesh, Meghalaya, Mizoram, Nagaland, Orissa, Sikkim, Tripura, Uttarakhand, Uttar Pradesh and West Bengal), Bangladesh, Bhutan, Nepal, Indo-China, North Tanzania (perhaps introduced) and Thailand.

Flowering records: Gamble (1896) and Bahadur (1980) from Dehra Dun, Uttarakhand; Bahadur (1980) from Garo Hill, Meghalaya and Lower Himalaya; Barooah (1999) and Barooah and Borthakur (2003) from Lakhimpur and Sonitpur districts of Assam; Sharma (2008) from Sikkim; Anantachote (1987) from Thailand.

3. Bambusa vulgaris Schrad. ex J.C. Wendl., Coll. Pl. 2: 26, t.47. 1808; Munro, Trans. Linn. Soc. 26 (1): 106. 1868; Kurz, Prelim. Rep. Forest Pegu 93. 1875; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 43, t.40. 1896, in Hook.f., Fl. Brit. India 7: 391. 1896; E.G. Camus, Bambusées 122, t.76A. 1913; Bor, Fl. Assam 5: 34. 1940; R.B. Majumdar in S. Karthikeyan *et al*., Fl. Ind. Enumerat. - Monocot. 275. 1989; D.N. Tewari, Monogr. Bamboo 51. 1992; U. Shukla, Grasses N.E. India 190, t.50D. 1996; K.K. Seethal. & M. Kumar, Bamboos India 83, t.23. 1998; Barooah & Borthakur, Diversity Distrib. Bamboos Assam 82, t.18. 2003; S. Chowdhury, Assam's Fl. 304. 2005; Naithani *et al*., Distrib. Bamboo Sp. Manipur 99. 2010; K.C. Koshy, Bamboos TBGRI 41. 2010. **Figs. 3, 7e**

The species is represented by two varieties *viz.* var. *vulgaris* and var. *vittata* Rivière & C. Rivière. Out

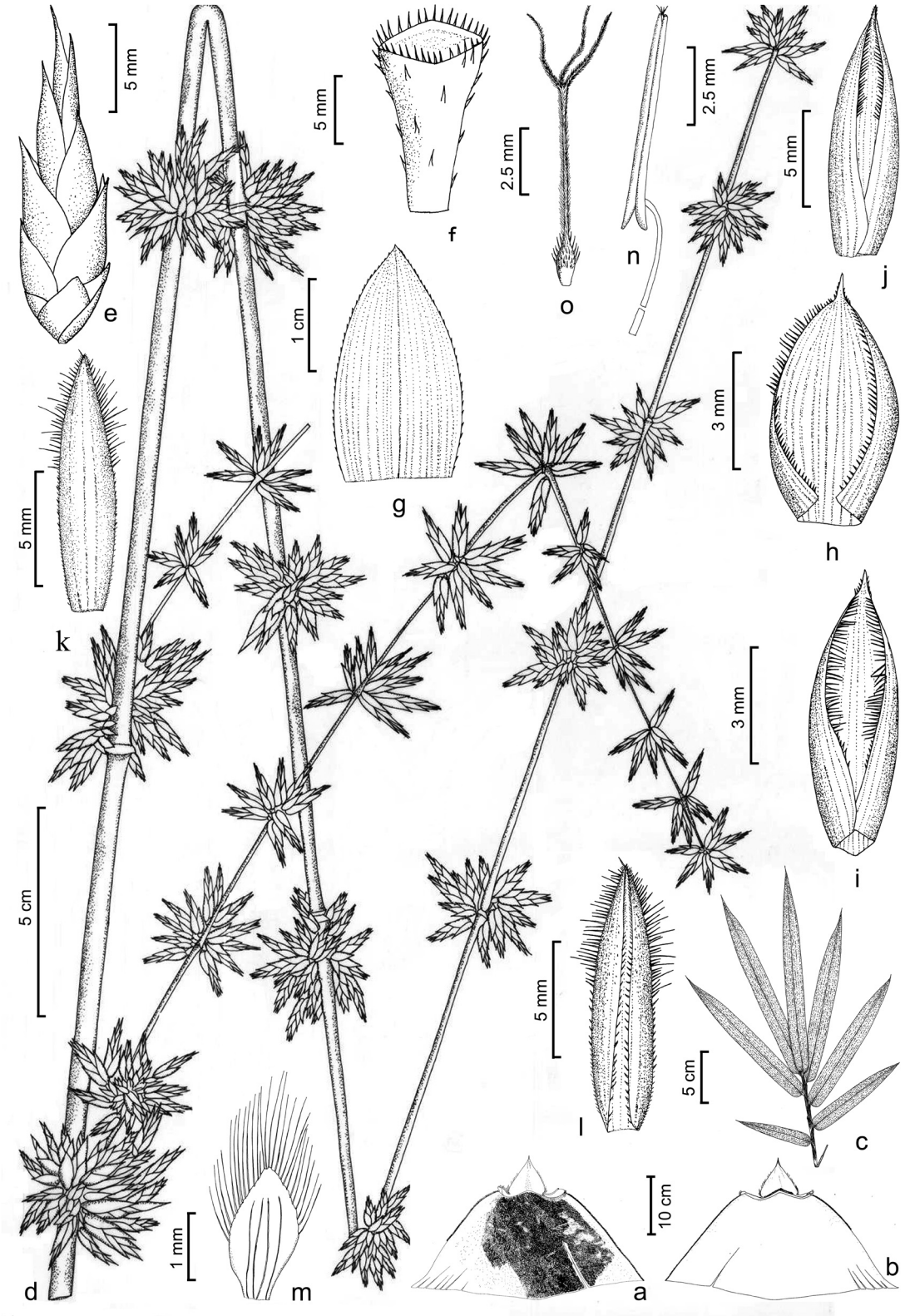

Fig. 3. *Bambusa vulgaris* Schrad. ex J.C. Wendl.: **a.** Adaxial view of culm sheath; **b.** Abaxial view of culm sheath; **c.** Leaf twig; **d.** Inflorescence; **e.** Spikelet; **f.** Rachilla; **g.** Bract; **h.** Prophylated bract; **i.** Glume; **j.** Lemma; **k.** Abaxial view of palea; **l.** Adaxial view of palea; **m.** Lodicule; **n.** Stamen; **o.** Pistil

of these, we observed flowering only in the typical variety (var. *vulgaris*).

var. vulgaris.

Vernacular name: **Assamese** – *Telai banh*; **Bengali** – *Bakal, Jai Barua*; **Manipuri** – *Bakal*; **Orissa** – *Sunderkania bansa*.

Type: Indien, Das Vaterland, *s.d.*, *s.l.*, *s.n.*, Acc. No. BM000578853 (BM, digitized image!).

Rhizomatous, loosely caespitose. Culms 10–22 m high, 6–13 cm in diameter, glossy, bright yellowish-green, polished; lower nodes with ring of rootlets; internodes 10–40 cm long. Culm sheaths deciduous; sheath proper 13–18 cm long, 30–32 cm broad at base, attenuated to the top to 7–10 cm broad mouth, rounded to concavely truncate at top, striate, blackish-brown hairs densely appressed on abaxial surface, both surfaces having sparsely distributed black, erect, bulbous at base and tip hairs, one margin ciliate directed downwards, other ciliate on upper half directed upward; imperfect blade erect, triangular, 4–8 cm long and 4–7 cm broad at base, continued with sheath proper, acute at apex, blackish-brown, comparatively longer, hairs densely appressed on adaxial surface at base, pale-yellowish short, densely hairy towards upper portion, brownish hairs appressed on abaxial surface associated with blackish, erect, bulbous base and tiped hairs, margins with bristles like cilia. Ligule 2–3 mm broad, irregular, dentate, sometimes fimbriate. Auricles 2, subequal, falcate, erect, continuous with blade, 1–1.5 cm high, 1–3 cm width at base, pale-yellow, 4–7 mm long, stiff, bristles at margin, glabrous on adaxial surface, yellowish-brown densely hairy on abaxial surface mixed with black, erect hairs with bulbous base and tip. Leaf-blades narrowly to broadly lanceolate, 11–23 × 1.3–3.5 cm, equal and attenuate at base, acute-acuminate at tip, glabrous on both surfaces when mature, margins scabrous; midvein prominent; secondary veins 6–8 pairs on either side; intermediate veins 8–9. Leaf sheath striate, glabrous to sparsely hairy, margins ciliate. Auricle small with bristles. Ligule *c.* 0.5 mm long, ciliate. Inflorescence paniculate, veriticillaster or spicate; branches arising from nodes. Spikelet *c.* 1.5–2 cm long, 4–7-flowered, two cleft at apex at maturity. Bract ovate, 1.3–2.5 × 0.8–1.2 cm, acute at apex, 20–24 nerved on either side of the prominent midrib, glabrous, minutely denticulate at margins. Prophyllated bract one, ovate, *c.* 6 × 4 mm, mucronate, 16-nerved, glabrous both surfaces, ciliate at margins with long cilia at middle portion. Prophyllated bud 2–3, subtended by prophyllated bract. Glumes 1–2, ovate-lanceolate, *c.* 7 × 4 mm, mucronate, 16-nerved, glabrous at both surfaces, margins ciliate at upper half, cilia directed somewhat downward, scabrous on lower half. Rachilla *c.* 2 mm long, hairy at mouth, sparsely hairy throughout. Lemma lanceolate-ovate, *c.* 12 mm long, mucronate, 16-nerved, transverse veins present, margins ciliate at upper half. Palea linear-lanceolate, *c*. 11 mm long, acute-obtuse at apex, glabrous on adaxial surface, pubescent on abaxial surface, pubescent at tip, ciliate throughout margins, 2-keeled; long ciliate at upper half, scabrous at lower half, 3-nerved in between keels. Lodicules 3, unequal, 2–2.2 mm long, cuneate at base, pointed at tip, 3–4 nerved, white-grey, membranous, hyaline, fimbriate at upper half. Stamens 6; filament *c*. 1.3 cm long; anther *c*. 7 × 1.5 mm, versatile, penicillate at apex. Pistil *c.* 10 mm long; ovary narrowly oblong, *c*. 1.5 mm long, sessile, obtuse at apex, lower portion glabrous, upper portion pubescent. Caryopsis not seen.

Habitat: Found only in cultivation.

Specimens examined: INDIA, **Assam**, Barak Valley, Cachar dist., Irongmara, near market, 20.04.2010, *M. Devi & D. Bhattacharyya* 10601, 10602; Joynagar, 04.03.2012, *M. Devi & D. Bhattacharyya* 10850; near NIT campus, Silchar, 11.03.2012, *M. Devi & D. Bhattacharyya* 10871 (Herbarium Dept. Life Science & Bioinformatics, Assam University, Silchar).

Distribution: India (Andaman & Nicobar Islands, Arunachal Pradesh, Assam, Kerala, Madhya Pradesh, Manipur, Orissa, West Bengal), Bangladesh, China, Hawaii islands, Indonesia, Jamaica, Malaya, New Guinea, Philippines, Singapore and Sri Lanka.

Flowering records: Blatter (1930) from Calcutta, West Bengal; Koshy and Harikumar (2000) from Kerala; Bhola (2006) and Bhol and Nayak (2010) from Orissa; Naithani *et al*. (2008) from Andaman and Nicober Islands. Gamble (1896), Blatter (1930), Ahmed and Das (1986) and Banik (1987) from Bangladesh; Gamble (1896) from Malaysia; Gamble (1896) and Blatter (1930) from Singapore; Gamble (1896), Blatter (1930) and Soderstrom and Ellis (1988) from Sri Lanka; Koshy and Harikumar (2000) from Philippines, China and Hawaii Islands.

4. Dendrocalamus longispathus (Kurz) Kurz, Prelim. Rep. Forest Pegu app. B 94, in clavi. 1875; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 89, t. 78. 1896, in Hook.f., Fl. Brit. India 7: 407. 1896; Brandis,

Indian Trees 677. 1906; E.G. Camus, Bambusées 157, t. 88A. 1913; Blatt., J. Bombay Nat. Hist. Soc. 33: 912. 1930; Bor, Fl. Assam 5: 12. 1940; Deb, Fl. Tripura 2: 506. 1983; D.N. Tewari, Monogr. Bamboo 69. 1992; U. Shukla, Grasses N.E. India 201, t.44A. 1996; K.K. Seethal. & M. Kumar, Bamboos India 114, t.32. 1998; Barooah & Borthakur, Diversity Distrib. Bamboos Assam 120, t.25. 2003; S. Chowdhury, Assam's Fl. 305. 2005; H.B. Naithani *et al*., Distrib. Bamboo Sp. Manipur 118. 2010; K.C. Koshy, Bamboos TBGRI 55. 2010.

Bambusa longispatha Kurz, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 42(4): 250. 1874. **Figs. 4, 7f**

Vernacular names: **Bengali –** *Khang*; **Darlong Tribal Language –** *Rinal;* **Manipuri** – *Unal*; **Tripura** – *Rupai.*

Type: Burma, 'Burmah', Pegu, *s.d.*, *S. Kurz s.n.*, Fl. (K, digitized image!).

Rhizomatous, caespitose, erect, straight. Culms 8–20 m high, 5–12 cm in diameter, glaucous-greyish green; lower nodes with rootlets; internodes 20–55 cm long. Culm sheaths persistent or deciduous; sheath proper 45–50 cm long, 19–28 cm broad at base, *c*. 3 cm broad at mouth, glabrous at margin, golden-brown, deciduous hairs densely appressed on abaxial surface, glabrous and shining on adaxial surface with powdery masses; imperfect blade deciduous, recurved, lanceolate, *c*. 30 cm long and 3.3 cm broad at base, acuminate at apex, minutely scabrous at margin, yellowish-brown dense hairs at base. Ligule *c*. 3 mm long, membranous, papery, serrate and fringed. Auricle absent. Leaf blades ovate-oblong-lanceolate, 10–26 × 2–4.1 cm, acuminate-acute at apex, glabrous adaxially, pubescent with white, silvery hairs abaxially, scabrous at margins; midnerve prominent, glabrous except base of midnerve hairy on adaxial surface; secondary nerves 8–10 pairs, prominent; tertiary nerves 7–8, cross veinlets present; pseudopetiole 4–6 mm long. Leaf sheath compressed-terete, striate, light yellow, pubescent abaxially, glabrous at margins. Ligule up to 2 mm long, papery, membranous, with long fringed hairs at mouth. Auricles fringed hair like. Inflorescence a large spicate panicle. Spikelets usually 2-flowered, hermaphrodite, clustered in sub-globose head; head 5–13 × 3–11 mm, surrounded by two bracts. Bracts acute, *c*. 6 mm long, 1-keeled, pubescent on abaxial surface. Spikelet *c*. 6 mm long, laterally compressed, hermaphrodite, blunt. Glumes 2; lower glume gibbous-obovate, *c*. 3.5 mm long, blunt at apex, laterally compressed, faintly 5-nerved, scarcely pubescent on abaxial surface; upper glume obovate, *c*. 5 mm long, blunt-acute at apex, membranous, 16-nerved, glabrous. Rachilla suppressed. Lemma obovate, *c*. 5 × 4 mm, blunt-acute at apex, 17-nerved, minute transverse veins with undulating lower part, membranous, scarcely pubescent on abaxial surface, ciliate at margins. Palea oblong, *c*. 5 × 0.8 mm, truncate-acute at apex, 2-keeled; keels ciliate, faintly 1–3-nerved. Lodicules absent. Stamens 6, exserted; filaments short; anthers *c*. 3.5 × 0.8 mm, glabrous, with a reddish or black mucro at tip. Ovary broadly ovoid, *c*. 1 mm long, acute at apex, pubescent, with a short glabrous stalk; style short, pubescent; stigma one, plumose. Caryopsis dry, ovoid, minute, *c*. 2.6 × 2 mm, narrow depression on middle, glabrous, beaked at apex at base of the style; style persistent on caryopsis.

Habitat: Common in homegardens; also distributed in wild hilly tracts.

Specimen examined: INDIA, **Tripura**, Dhalai district, Nalkata village, alt. 33 m, 24° 04′ N, 91° 59′ E, 03.05.2013, *L. Darlong* 10394. (Herbarium Dept. Life Science & Bioinformatics, Assam University, Silchar).

Distribution: India (Assam, Bihar, Kerala, Manipur, Meghalaya, Mizoram, Orissa, Tripura, Uttarakhand, West Bengal, Western Peninsula), Bangladesh, Myanmar and Thailand.

Flowering records: Gupta (1972) from Cachar district of Assam; Gupta (1972), Mohan Ram and Hari Gopal (1981) and Pathak and Kumar (2000) from Mizo Hills, Mizoram; Seethalakshmi and Kumar (1998) from Kerala. Devi *et al*. (2014) from Tripura; Gamble (1896), Anonymous (1928, 1930), Blatter (1930) and Banik (1985) from Bangladesh ; Gamble (1896) and Blatter (1930) from Myanmar.

5. Melocalamus compactiflorus (Kurz) Benth. in Benth. & Hook.f., Gen. Pl. 3(2): 1212. 1883; Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 94, t. 84, 1896, in Hook.f., Fl. Brit. India 7: 409. 1896; E.G. Camus, Bambusées 161, t.94f.C. 1913; Barooah & Borthakur, Diversity Distrib. Bamboos Assam 142, t.32. 2003; Naithani *et al*., Distrib. Bamboo Sp. Manipur 129. 2010; K.C. Koshy, Bamboos TBGRI 67. 2010. *Pseudostachyum compactiflorum* Kurz, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 42(4): 252. 1874. *Dinochloa compactiflora* (Kurz) Mc Clure, Bull. Misc. Inform. Kew 1: 253. 1936; Bor, Fl. Assam 5: 23. 1940; Deb, Fl. Tripura 2: 507. 1983; D.N. Tewari, Monogr. Bamboo 82. 1992; U. Shukla, Grasses N.E. India 206. 1996; K.K. Seethal. & M. Kumar, Bamboos India

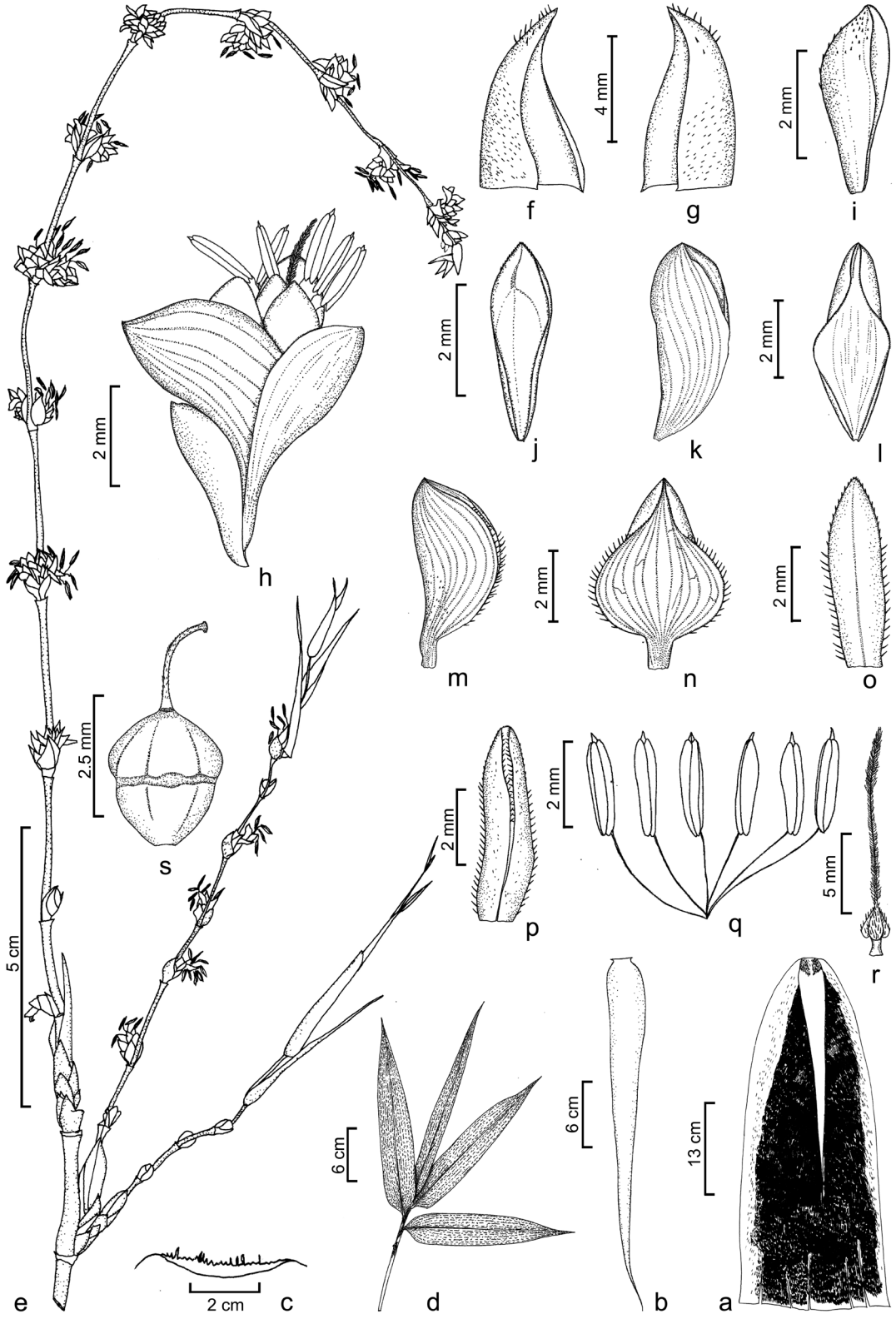

Fig. 4. *Dendrocalamus longispathus* (Kurz) Kurz: **a.** Culm sheath; **b.** Imperfect blade; **c.** Ligule of culm sheath; **d.** Leaf twig; **e.** Inflorescence; **f** & **g.** Bracts; **h.** Spikelet; **i.** Lower glume (side view); **j.** Adaxial view of lower glume; **k.** Upper glume (side view); **l.** Adaxial view of upper glume; **m.** Lemma (side view); **n.** Adaxial view of lemma; **o.** Abaxial view of palea; **p.** Adaxial view of palea; **q.** Stamens; **r.** Pistil; **s.** Fruit.

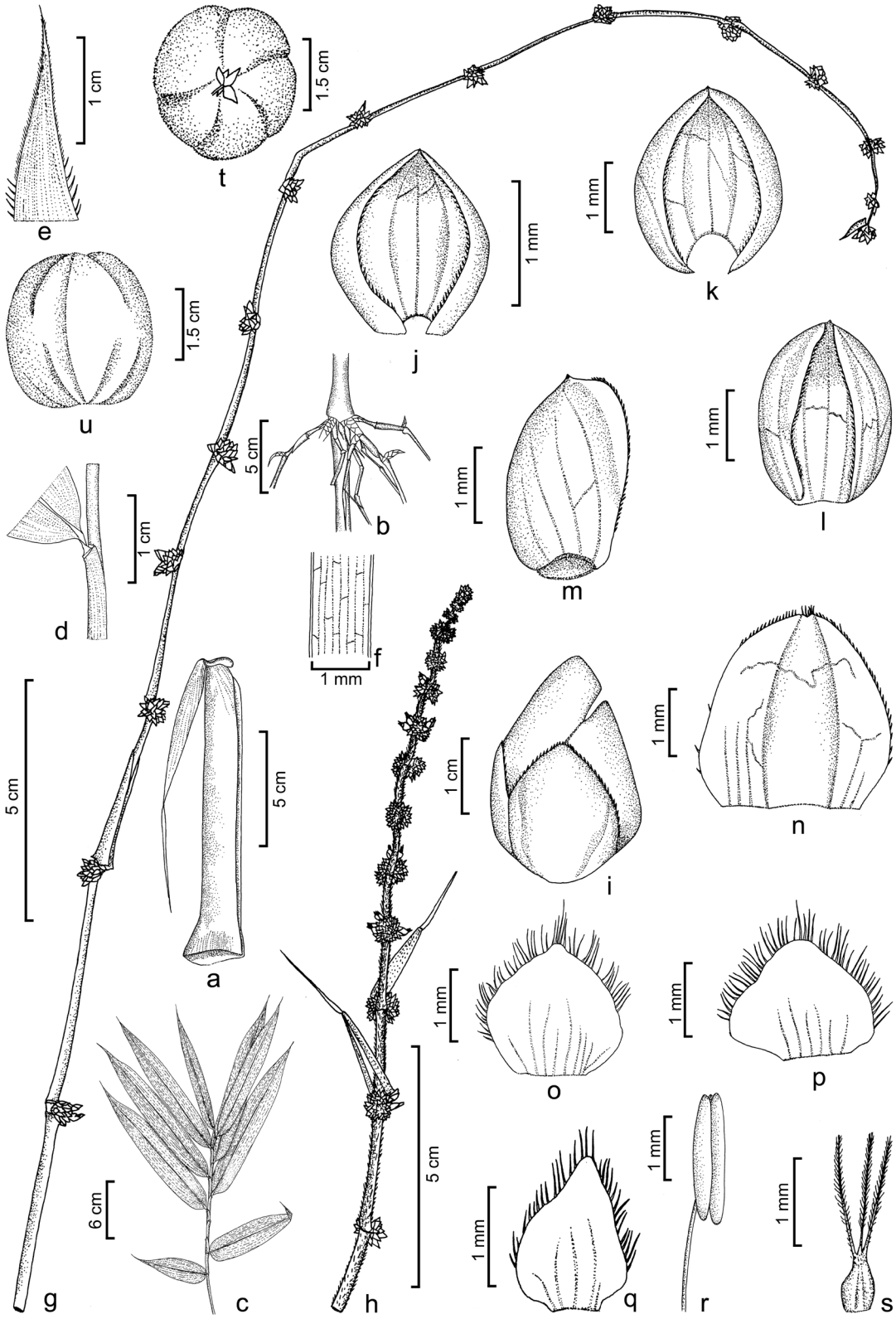

Fig. 5. *Melocalamus compactiflorus* (Kurz) Benth.: **a.** Culm sheath; **b.** Node with branches; **c.** Leaf twig; **d.** Leaf base & ligule; **e.** Leaf apex; **f.** Leaf veins; **g** & **h.** Inflorescence twigs; **i.** Spikelet; **j.** Lower glume; **k.** Upper glume; **l.** Lemma front view; **m.** Lemma (side view); **n.** Palea; **o**, **p** & **q.** Lodicules; **r.** Stamen, **s.** Pistil; **t.** Fruit (top view); **u.** Fruit (side view).

144, t.42, 1998; S. Chowdhury, Assam's Fl. 305. 2005 . **Figs. 5, 7g & h**

Type: BURMA, 'Birma', Karen Hills, *s.d.*, *S. Kurz* 3183, fl. & fr. (BM, digitized image!).

Vernacular names: **Assamese –** *Beti banh*; **Bengali –** *Daral, Lata bans, Nal bans*.

Rhizomatous, climbing. Culms solid, greyish-green, arching and spreading over tall trees, 10–35 m long, 1–3 cm in diameter; nodes swollen; internodes 20–60 cm long. Culm sheaths shorter than the internodes, persistent, linear, cylindrical, hard, longer than broad, yellow, tightly covering the culm; sheath proper *c*. 13 cm long and *c*. 7.5 cm broad at base, base of culm-sheath much swollen, attenuate at mouth to *c*. 2.5 cm broad, prominent striations present up to 1.5 cm upwards from base, truncate at top, abaxial surface smooth with white powdery mass, somewhat shiny, deciduous white hairs densely appressed associated with deciduous, black bulbous based hairs; imperfect blade narrowly triangular, *c*. 11.5 × 2.5 cm, *c*. 0.8 cm broad at base, acuminate at apex, rounded at base, reflexed, striate, glabrous adaxially, sparsely yellow-brownish appressed hairy abaxially, margins glabrous. Ligule minute, *c*. 0·5 mm, entire. Auricles falcate, wing-like, 0.3–0.4 × 0.8–1.2 cm, glabrous, recurved. Leaves 9–13 per twig, drooping. Leaf blades narrowly oblong-lanceolate, 8–26 × 1.8–4.1 cm, unequally rounded and attenuate at base, acuminate with long cilia at apex, glabrous both surfaces except nerve scabrid along one margin on adaxial surface, margins serrate; midvein prominent, glabrous; secondary veins 7–9 pairs; tertiary veins 5–7, mostly 7; cross-veins not prominent on adaxial surface but prominent on abaxial surface, oblique; pseudo-petiole 2–3 mm long. Leaf sheaths striate, glabrous, smooth at margins, ending into triangular shaped callus; callus glabrous. Ligule *c*. 1 mm high, glabrous, truncate. Inflorescence a panicle with congested spikelets in heads. Spikelets very small, 2.5–3 × *c*. 2 mm, blunt at top, 2-cleft, glabrous. Glumes 2, broadly ovate, blunt at apex with a very short mucro, glabrous both surfaces, margins finely ciliate; lower glume *c*. 1.5 mm long, 3-nerved; upper glume *c*. 2.5 mm long, 7-nerved. Fertile florets 2, both hermaphrodite. Rachilla suppressed. Lemma similar to upper glume in shape and size, membranous, 11-nerved, glabrous both surfaces, margins ciliate. Palea broadly ovate, boat-shaped, 2.5–2.8 mm long, membranous, 2-keeled; keels ciliate, 3–5-nerved on either side of keels; glabrous both surfaces. Lodicules 3, ovate, 5–14-nerved, fimbriate at margins, vary in size; one *c*. 2 mm long; other two *c*. 1.5 mm long. Stamens 6, free; filaments short; anthers *c*. 2 mm long, acute at tip, glabrous. Pistil minute, *c*. 2 mm long; ovary ovoid, glabrous; style short, thick; stigmas 3, short, plumose. Caryopsis sub-globose, 2–3.5 cm in diameter, fleshy, green, depressed at summit with persistent glumes at base.

Habitat: Commonly occurring in wild hilly tracts.

Specimens examined: INDIA, **Assam,** Barak Valley, Cachar, Bondukmara, 24.01.2013, *M. Devi & D. Bhattacharyya* 11005; Bondukmara, 24.01.2013, *M. Devi & D. Bhattacharyya* 11023 (Herbarium Dept. Life Science & Bioinformatics, Assam University, Silchar).

Distribution: India (Arunachal Pradesh, Assam, Kerala, Manipur, Meghalaya, Mizoram, Nagaland, Tripura, Uttarakhand), Bangladesh, China, Myanmar, Thailand and Vietnam.

Flowering records: Mohan Ram and Hari Gopal (1981) from Mizoram; Bahadur and Naithani (1983), Seethalakshmi and Kumar **(**1998) and Devi and Bhattacharyya (2013b) from Cachar district, Assam; Seethalakshmi and Kumar **(**1998) and Barooah and Borthakur (2003) from FRI bambusetum, Dehra Dun, Uttarakhand; Anonymous (1928) from Bangladesh; Seethalakshmi and Kumar **(**1998) from Myanmar.

Report of flowering of this species from Manipur in 1973 (Malick, 1974) is erroneous (Bahadur & Naithani, 1983) as based on a misidentified specimen.

6. Schizostachyum dullooa (Gamble) R.B. Majumdar in S. Karthikeyan *et al*., Fl. Ind. Enumerat. - Monocot.: 281. 1989; D.N. Tewari, Monogr. Bamboo 132. 1992; U. Shukla, Grasses N.E. India 218, t. 47B. 1996; K.K. Seethal. & M. Kumar, Bamboos India 240, t.80. 1998; Stapleton in Noltie, Fl. Bhutan 3(2): 497. 2000; Barooah & Borthakur, Diversity Distrib. Bamboos Assam 164, t.39. 2003; S. Chowdhury, Assam's Fl. 309. 2005; Naithani *et al*., Distrib. Bamboo Sp. Manipur 142. 2010. *Teinostachyum dullooa* Gamble, Ann. Roy. Bot. Gard. Calcutta 7: 101, t.89. 1896; Gamble in Hook. f., Fl. Brit. India 7: 411. 1896; Brandis, Indian Trees 679. 1906; E.G. Camus, Bambusees 164, t.92A. 1913. *Neohouzeaua dullooa* (Gamble) A. Camus, Bull. Mus. Natl. Hist. Nat. 28: 101. 1922; Gamble, Kew Bull. 90. 1923; Bor, Fl. Assam 5: 21. 1940; Deb, Fl. Tripura 2: 523. 1983. **Figs. 6, 7i & j**

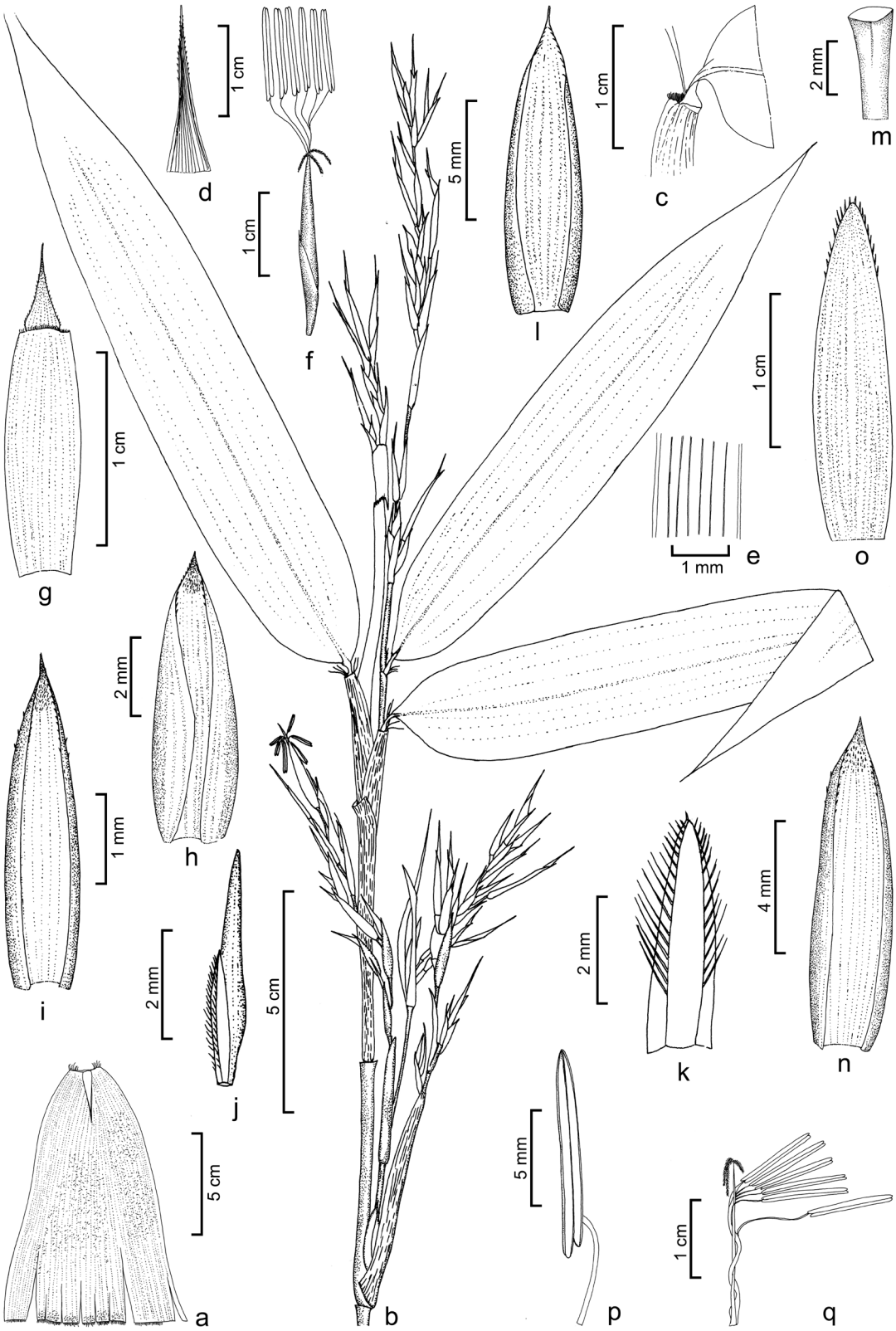

Fig. 6. *Schizostachyum dullooa* (Gamble) R.B. Majumdar: **a.** Culm sheath; **b.** Leafy inflorescence; **c.** Leaf base & ligule; **d.** Leaf apex; **e.** Leaf veins; **f.** Spikelet, **g.** Spathaceous bract; **h.** & **i.** Gemmiperous bract; **j.** Prophyllated bud; **k.** Palea surrounding the prophyllated bud; **l.** Bract; **m.** Rachis; **n.** Glume; **o.** Lemma; **p.** Stamen; **q.** Stamens & pistil.

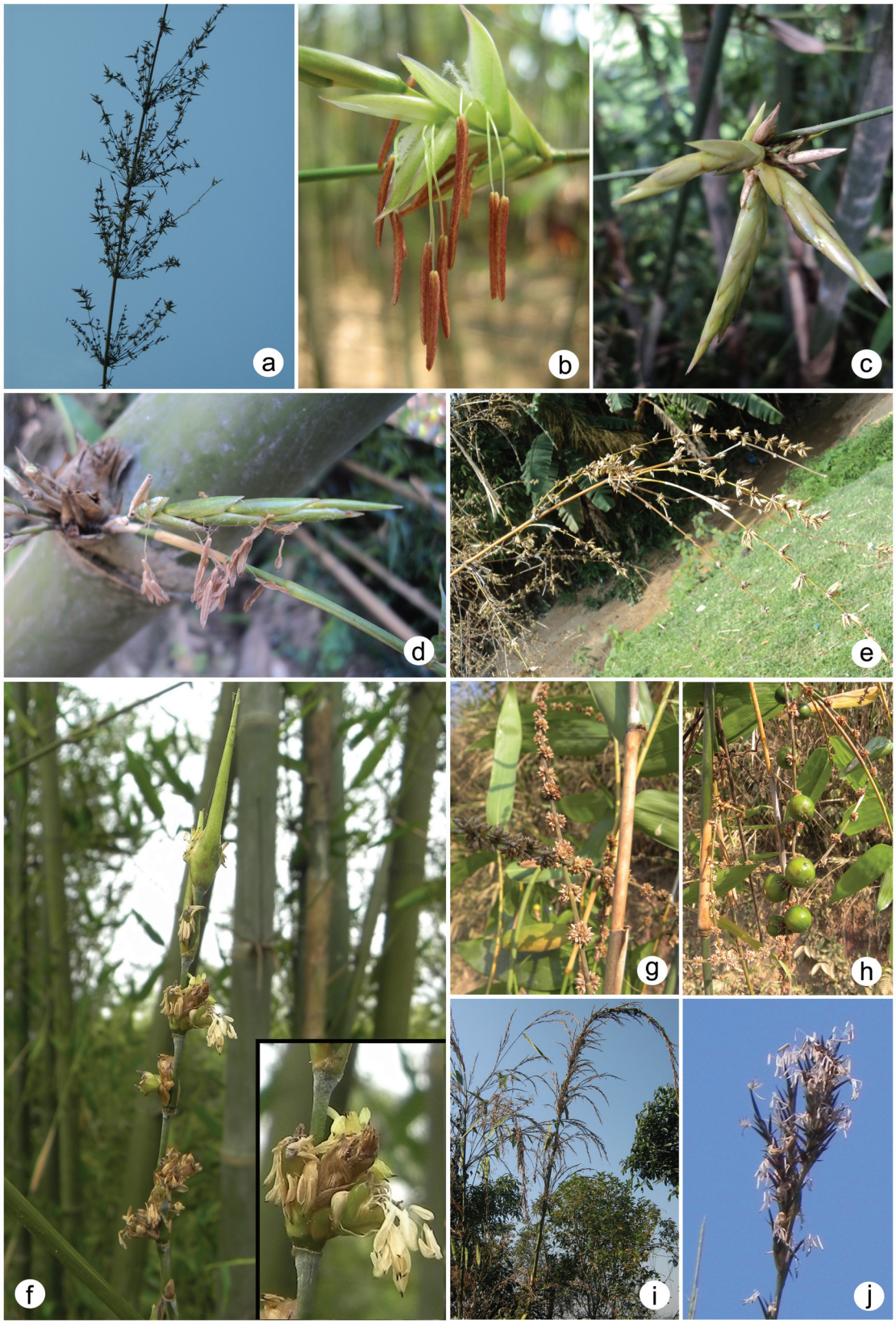

Fig. 7. a-c. *Bambusa cacharensis* R.B. Majumdar, **a.** Portion of Inflorescence, **b.** Single Spikelet, **c.** Cluster of Spikelets; **d.** *Bambusa nutans* Wall. ex Munro - Spikelet; **e.** *Bambusa vulgaris* Schrad. ex J.C. Wendl. var. *vulgaris* - portion of Inflorescence; **f.** *Dendrocalamus longispathus* (Kurz) Kurz - portion of Inflorescence (inset: Spikelets); **g** & **h.** *Melocalamus compactiflorus* (Kurz) Benth., **g.** Portion of Inflorescence, **h.** Portion of Infructescence; **i** & **j.** *Schizostachyum dullooa* (Gamble) R.B. Majumdar, **i.** Culms with gregarious flowering, **j.** Portion of Inflorescence.

Type: Upper Burma, Katha, Hawyaw, Monastery compound, February 1892, *W. Oliver s.n.*, Fl. (K, digitized image!).

Vernacular names: **Assamese** – *Dullooa, Dolu banh*; **Bengali** – *Dolu bans*; **Garo** – *Wadroo*, **Lepcha** – *Puksalu*.

Shrubby, 5–8 m high, deciduous, erect, straggling, lofty hairy on entire culm, white powdery ring below the nodes; culms sometimes slightly bend at nodes; internodes up to 64 cm long, wall *c.* 5 mm thick. Culm sheaths deciduous, sometimes persistent; sheath proper variable in size, 7–13 cm long and 5.5–8.5 cm broad at base, gradually attenuate upwards to 3 mm broad mouth with bristle like hairs on either sides, striate, yellowish, shiny, truncate-rounded at mouth, concave, dense hairy ring at base on abaxial surface at point of attachment with node; black, bulbous-based hairs associated with whitish-golden hairs appressed on abaxial surface; glabrous adaxially; imperfect blades subulate, 0.5–2.6 cm long, striate, recurved, sometimes erect, minutely bulbous based hairy on both surfaces, entire at margins. Ligule short, *c.* 1 mm long, entire, auricles absent. Leaf-blades linear, oblong-lanceolate, 11–20 × 1.5–3.1 cm, smooth at both surfaces, rounded at base, attenuated to a short pseudopetiole; pseudopetiole *c.* 3 mm long; midvein prominent at least half of leaf-blade; secondary veins 6–7 pairs; intermediate 6–7; transverse veinlets absent. Leaf sheaths striate, smooth, ciliate on margins, ending in callus with long bristles. Ligule short, *c.* 1 mm long, fimbriate. Inflorescence a bractiferous panicle, linear clusters of spike-like spikelets subtended by spathaceous bracts. Spikelets usually four in a spicate branch; terminal spikelet with one hermaphrodite floret lacking palea, others sterile with a small palea. Spathaceous bract 1.7–2.8 cm long, aristate, ciliate at apex. Gemmiperous bract 2, linear-lanceolate, unequal, 7–10 mm long, cylindrical, 10–14-nerved, both surfaces minutely pubescent on upper half. Prophyllated bud 2, subtended by a palea. Bract linear-lanceolate, cylindrical, *c.* 1.3 cm long, mucronate at apex, 12–14-nerved, margins ciliate at apex, both surfaces glabrous. Spikelets *c.* 2.1 cm long. Glumes 1–3, cylindrical, linear-lanceolate, *c.* 15 × 3 mm, shortly aristate or mucronate at apex, 12–14-nerved, both surfaces minutely pubescent on upper half. Rachilla somewhat laterally compressed, *c.* 3.4 cm long, glabrous. Florets with rachilla extension; fertile floret sessile. Lemma lanceolate-oblong, *c.* 2.1 × 0.4 cm, 14-nerved, acute-rounded at tip, tip edges ciliate, glabrous on both surfaces. Palea absent in fertile floret and present in sterile floret; palea *c.* 4 mm long, 2-keeled; keels long ciliate at upper half, nerve absent in between keels. Lodicules absent. Stamens 6; filaments connate up to top, glabrous; anthers *c.* 1.1 × 0.1 cm, unequal, sagittate at base. Pistil *c.* 2.3 cm long; ovary linear, elongated, glabrous continued to long glabrous style; stigmas 3, plumose, reddish pink. Caryopsis *c.* 4 mm long, fleshy, with 1–1.3 cm long persistent style.

Habitat: Common in open forests; also found in cultivation.

Specimens examined: INDIA, **Assam**, Barak Valley, Cachar district, Assam University Campus, near foot bridge, 01.03.2011, *M. Devi & D. Bhattacharyya* 10657; Motinagar, on the way to Bhuban hill, 92° 99′ 34″ E & 24° 64′ 86″ N, alt. 13.5 m, 02.03.2011, *M. Devi & D. Bhattacharyya* 10658, 10659; Chalta basti, 25.05.2011, *M. Devi & D. Bhattacharyya* 10703; Innerline Reserve Forest, 25.03.2012, *M. Devi & D. Bhattacharyya* 10873 (Herbarium Dept. Life Science & Bioinformatics, Assam University, Silchar).

Distribution: India (Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal), Bangladesh, Bhutan, Myanmar and Vietnam.

Flowering records: Nath (1962), Gupta (1972) and Nath and Das (2010) from Cachar district, Assam; Naithani and Garbyal (2010) from Mizoram; Rao and Ramakrishnan (1988) from Meghalaya; Anonymous (1927, 1946), Banik (1999), Gamble (1896) and Hasan (1973) from Bangladesh; Gamble (1896) and Blatter (1930) from Bhutan and Myanmar.

Discussion

Out of the total six species described here, *M. compactiflorus* and *S. dullooa* flowered gregariously whereas the rests showed sporadic flowerings. Fruit setting was observed in three species, *viz*. *D. longispathus*, *M. compactiflorus* and *S. dullooa* and seeds were found viable in all. Flowering followed by dying is one of the major causes of germplasam erosion of species from a particular area. Felling of bamboos by the villagers after flowering is also another threat. Hence, proper conservation planning should be initiated immediately by the forest departments, NGOs and other organizations working on bamboos.

Acknowledgements

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