

## ***Amaranthus saradhiana* (Amaranthaceae)—a new species from southern Western Ghats of Kerala, India**

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### **Abstract**

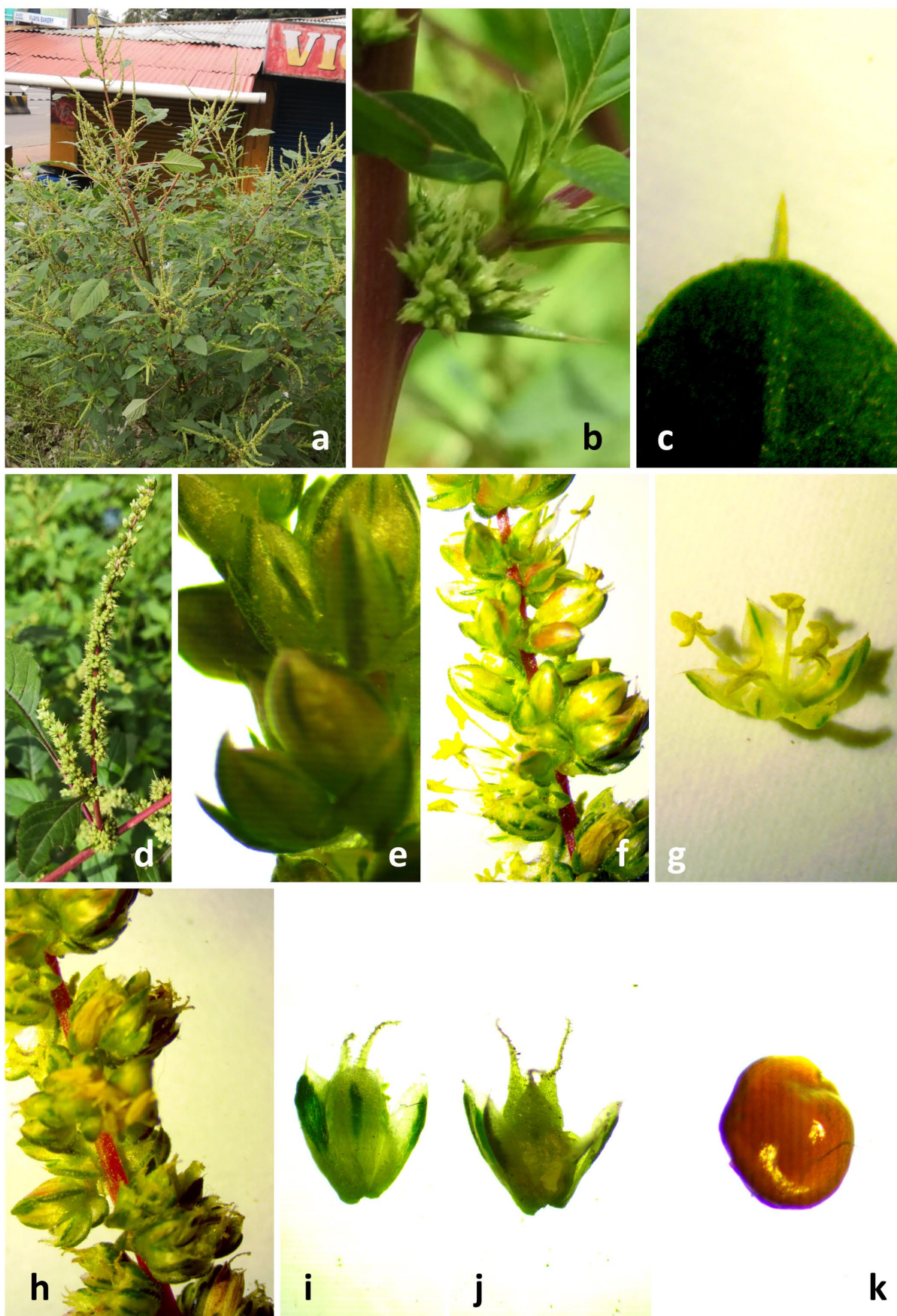
A new species of *Amaranthus* from the southern region of Kerala, India is described and illustrated as *Amaranthus saradhiana* sp. nov. SEM analysis of pollen and seed architectural patterns together with FTIR spectral banding discriminates the taxon from its morphologically allied species, *A. spinosus*. Detailed description including distribution with relevant taxonomic notes along with color photographs and sketches are provided.

**Keywords:** Novelty, south India, trifold stigma

### **Introduction**

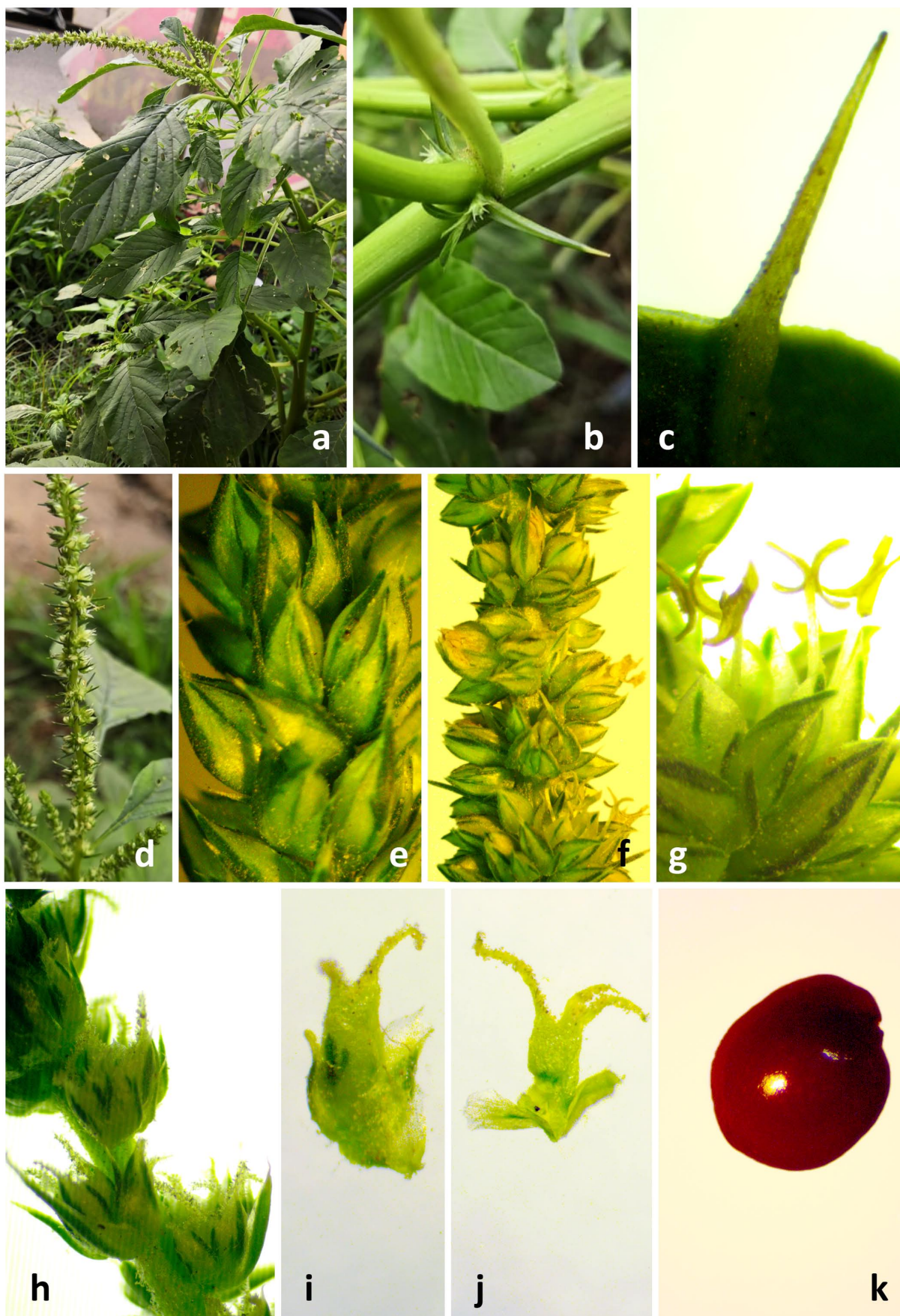
Amaranthaceae constitutes the biggest family under Caryophyllales (Cuenoud *et al.* 2002), which ca. 110 genera and 1700 species. The genus *Amaranthus* Linnaeus (1753: 989) is generally considered to be a ‘difficult’ genus consisting of about 60–70 species (Costea & DeManson 2001). Approximately 40 species are native to the Americas, the remaining ones to the other continents (Costea *et al.* 2001, Iamónico 2012). Most species are summer annual weeds and commonly referred to as pig weed (Bensch & Peterson 2003). Mosyakin and Robertson (1996) recognized three subgenera, *Amaranthus* subgen. *Acnida* (Linnaeus 1753: 1027) Aellen ex K.R. Robertson (1981: 283), *A.* subgen. *Amaranthus*, and *A.* subgen. *Albersia* (Kunth 1838: 144) Grenier & Godron (1856: 3) on the basis of the inflorescence structure and the floral features. The subgenus *Amaranthus* consists of 20 species of annual herbs which are monoecious (Mosyakin & Robertson 2003). The genus is critical from the taxonomic point of view because of its high phenotypic variability which paved the way for nomenclatural disorder and inappropriate naming (Iamónico 2010). The overall similarity among the various species, small and difficult-to-see diagnostic parts, intermediate forms, and the broad geographical distribution – all act as factors making the taxonomic characterization cumbersome (Achigan-Dako *et al.* 2014) and is the reason for many synonyms.

During the taxonomic revision of the family Amaranthaceae in Kerala, the topic of the Ph.D. thesis of the first author, we have conducted many extensive exploration surveys during 2014–2018. While exploring the Kulathupuzha region of Thiruvananthapuram district, we encountered an unknown *Amaranthus* species in February 2014. Critical studies on the collected materials revealed that the species is related to *Amaranthus spinosus* L. (1753: 991) a wide spread species, but differs in many characters. Detailed taxonomic studies with the perusal of relevant literature (Hooker 1886, Uline & Brey 1894, Gamble 1925, Naithani 1990, Abrams & Serrin 1944, Bojian *et al.* 2003, Boulous 2009, Palmer 2009, Das 2012, Iamónico 2015) and comparison with types and protologue proved this to be a species hitherto unknown to science, which is described here as *Amaranthus saradhiana* sp. nov.

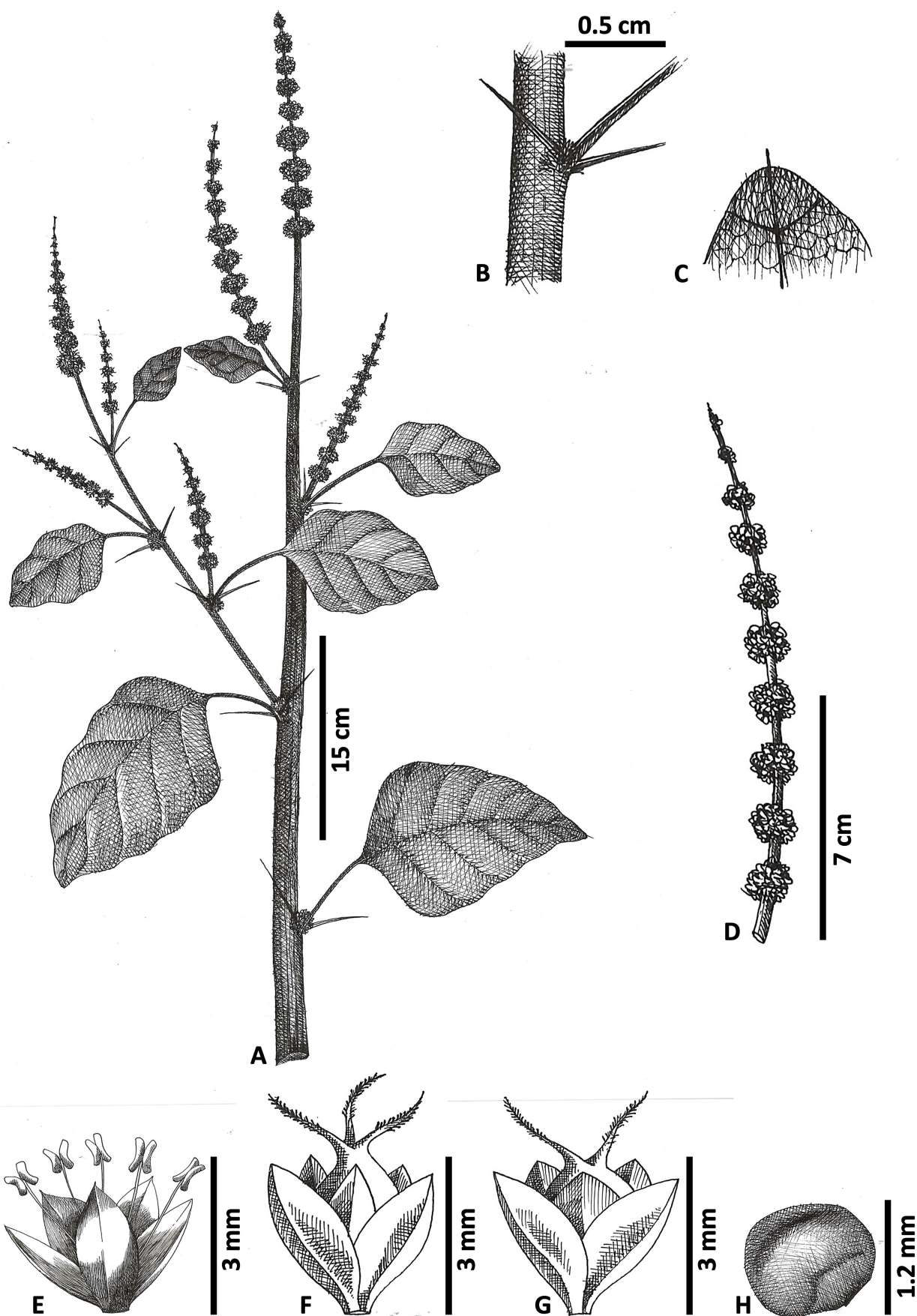


**FIGURE 1.** *Amaranthus saradhiana* a. Habit. b. Spine at the node. c. Protrusion at the leaf tip. d. Spike. e. Striped tepals. f. Cluster of male flowers. g. Male flower. h. Cluster of female flowers. i. Female flower with bifid stigma. j. Female flower with trifid stigma. k. Seed.



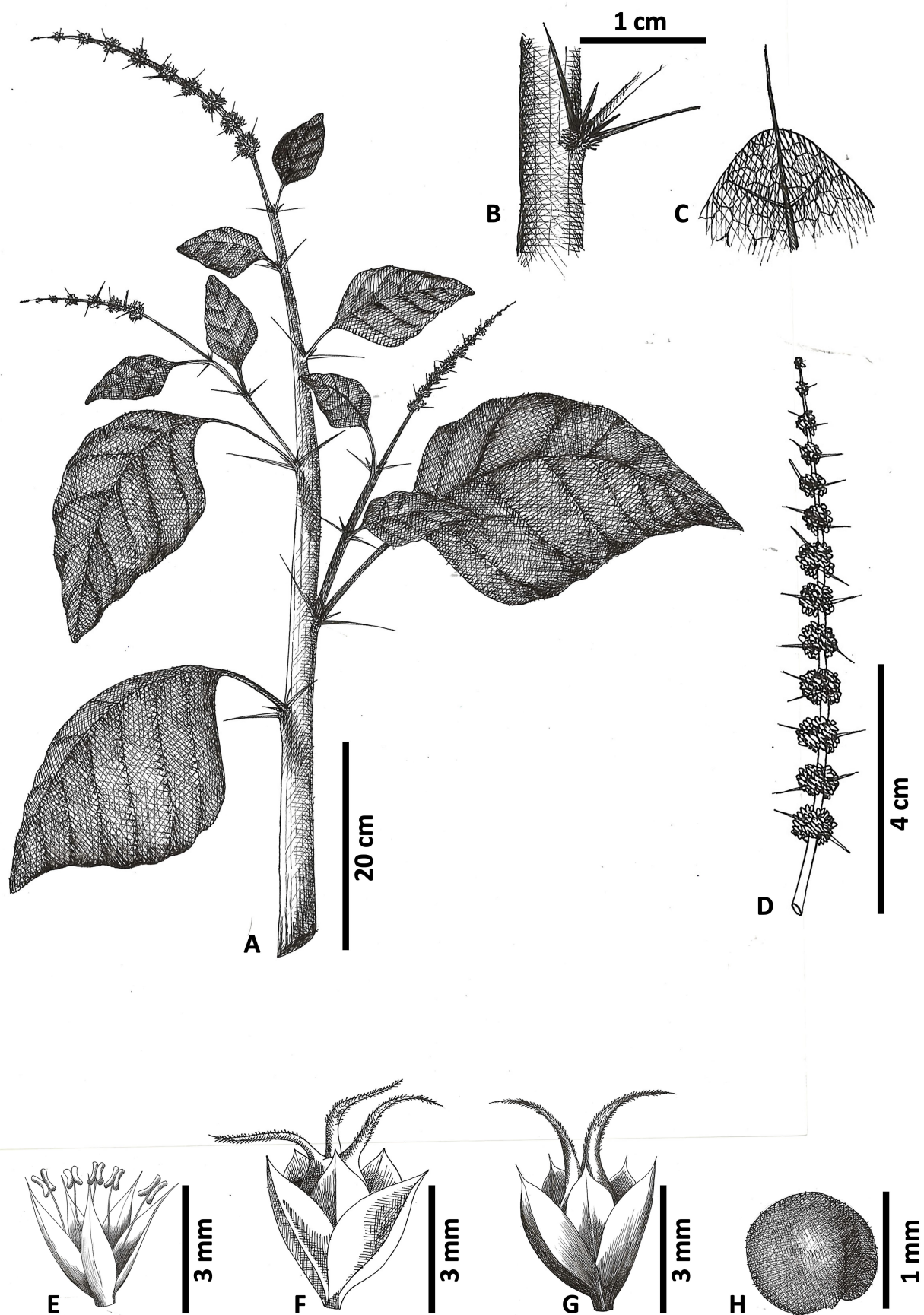


**FIGURE 2.** *Amaranthus spinosus* a. Habit. b. Spine at the node. c. Protrusion at the leaf tip. d. Spike. e. Striped tepals. f. Cluster of male flowers. g. Male flowers. h. Cluster of female flowers. i. Female flower with bifid stigma. J. Female flower with trifid stigma. K. Seed.

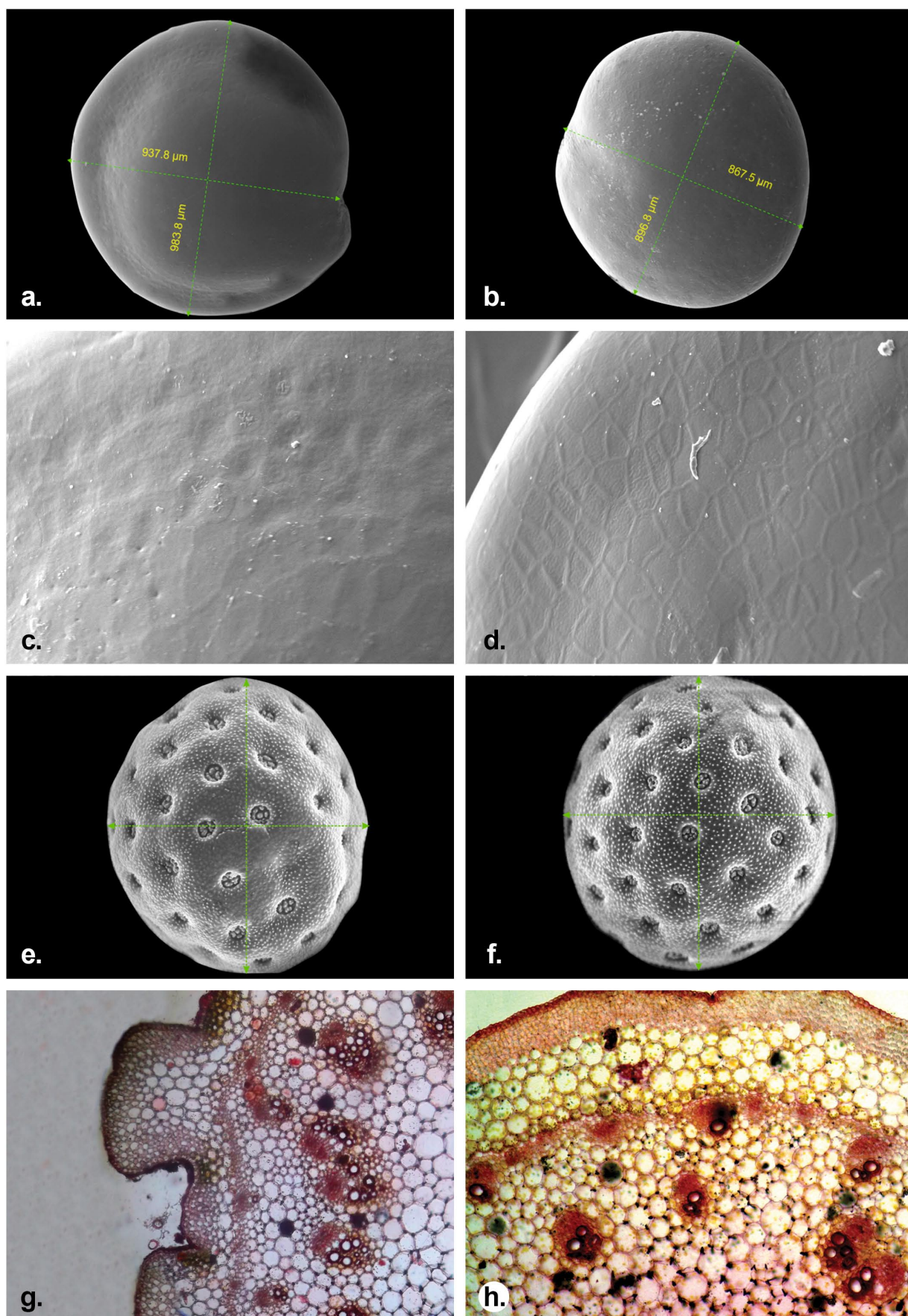


**FIGURE 3.** *Amaranthus saradhiana* a. Habit. b. Spine at the node. c. Protrusion at the leaf tip. d. Spike. e. Male flower. f. Female flower with trifid stigma. g. Female flower with bifid stigma. h. Seed.





**FIGURE 4.** *Amaranthus spinosus* a. Habit. b. Spine at the node. c. Protrusion at the leaf tip. d. Spike. e. Male flower. f. Female flower with trifid stigma. g. Female flower with bifid stigma. h. Seed.



**FIGURE 5.** a. *Amaranthus saradhiana* seed. b. *Amaranthus spinosus* seed. c. *A. saradhiana* seed surface. d. *A. spinosus* seed surface. e. *A. saradhiana* pollen. f. *A. spinosus* pollen. g. *A. saradhiana* stem C.S. h. *A. spinosus* stem C.S.



## Taxonomy

*Amaranthus saradhiana* S. Arya, V.S.A. Kumar, W.K. Vishnu & Rajesh Kumar *sp. nov.* (Fig 1. a–k, 3. a–h)

Diagnosis: The new species is morphologically similar to *Amaranthus spinosus* but differs by means of its sparsely pubescent stem having slightly undulating outline, purple color of stem and petiole, total absence of spines in the terminal spike, emergence of one spine from each node and prominent green stripes in tepals having acute apex in female flowers.

Type:—INDIA. Kerala: Thiruvananthapuram district, Palode, way to Kulathupuzha, 110 m, 8.970 N, 77.30E, 4th February 2017, V.S. Anil Kumar & S. Arya 86207 (Holotype: TBGT; Isotype: MH, CMPR)

Annual herb, about 80–100 cm high, profusely branched, branches with or without grooves, spinescent; spines arise from the leaf nodes, distributed throughout stem and branches; 0.4–0.5 cm long. Stem angular, erect ascendant, purple in color, glabrous or with sparse hairs. Leaves simple, alternate, petiolate; petiole terete, glabrous, 2–5 cm long; lamina 1.5–7.4 × 1.5–4.5 cm, ovate to lanceolate, base attenuate, margin entire, apex obtuse or emarginated; dark green, base tapering to slender, sparsely pubescent on the main veins below. Inflorescence cymose with long slender terminal or axillary spikes, axillary spikes are in sessile clusters, purple in color. Peduncle terete, purple coloured, sparsely pubescent. Bracts and bracteoles minute, 0.05–0.1 mm, apex ovate to lanceolate margin delate or rhombic, glabrous and white. Flowers unisexual, yellowish green in colour. Staminate flowers: confined to the terminal end of the spike, 3 mm across; tepals 5, 0.5–1.5 mm, calycine, unequal; stamens 5; anthers sagittate. Pistillate flowers: 4 mm across; tepals 5 1.5–2 mm with prominent green stripes, acute at apex; ovary 1-celled, pubescent; ovules solitary; stigma 2–3. Fruit shorter than perianth lobe. Seeds minute, more or less globose, 937.8 × 983.8 µm, a beak like extension near the hilum, spermoderm sculpturing faint, pollen grains spheroidal, polyaperturate, 22.46 µm across, spinulose exine sculpturing, visible frequency of pores range from 26–30, number of ectexinous bodies range from 3–5 with varying degrees of fusion. Fruit is an orbicular utricle, compressed. Fruiting throughout the year.

Flowering and fruiting:—June–December.

Etymology:—The species is named in recognition of Mrs. Saradhamma Venugopal, mother of the second author who used to give constant encouragement for doing botanical research.

Distribution and ecology:—The species occurs in dry waste lands and along the Palode–Kulathupuzha–Thenkasi road sides. The species is also found growing along the roadsides in Palayam, Thiruvananthapuram. Several accessions of the taxon has been collected by the authors from various districts of the state.

Additional specimens examined (Paratypes):—INDIA: Kerala: Thiruvananthapuram District, Jagathy to Poojappura, 18 m, 30th May 2017, V.S. Anil Kumar & S. Arya 87290 (TBGT), Alappuzha District, Vellakinar, 8 m, 12th September 2017, V.S. Anil Kumar & K. Vishnu Walsan 87295 (CMPR). Ernakulam District, Ernakulam–Kaloore route, 4 m, 9.9312° N, 76.2673° E, 22nd October 2017, V.S. Anil Kumar & T. Rajesh Kumar 87312 (CMPR). Kollam District, Shengottai–Kollam National Highway, 3 m, 8.9751° N, 77.2491° E, 10th October 2018, S. Arya & K. Vishnu Walsan 87338 (TBGT). Kannur District, Kannur–Thavakkara region, 1.02 m, 1° 52' 0" N, 75° 21' 55" E, 18th October 2018, V.S. Anil Kumar & K. Vishnu Walsan 87348 (TBGT). Kollam District, Kollam–Karunagappally region, 3 m, 9.0654° N, 76.5315° E, 22nd October 2018, S. Arya & T. Rajesh Kumar 87360 (CMPR). Alappuzha District, Cherthala–Alappuzha region, 11 m, 9.4981° N, 76.3388° E, 11th November 2018, V.S. Anil Kumar & K. Vishnu Walsan 87365 (TBGT).

### Taxonomic discrimination of *A. saradhiana* *sp. nov.* (Fig 1. a–k, 3. a–h) from *A. spinosus* (Fig 2. a–k, 4. a–h)

*Amaranthus saradhiana* looks deceptively similar to the common *A. spinosus*. But we can easily differentiate the new species from the latter by means of the absence of spines on the spikes, short spines on the stem (0.5–0.8). In *A. saradhiana*, usually one spine arises from the axil of each leaf while it is 2–3 for *A. spinosus*. Distribution of female flowers with 3 stigmas in the axillary and terminal position of the spike, purple color of the stem, spike and petiole also demarcates the new taxon. In *A. saradhiana*, seeds are minute, more or less globose, 937.8 × 983.8 µm with a beak like extension near the hilum. Spermoderm sculpturing is faint without conspicuous eruptive patterns (Fig 5.a & c). The seeds of *A. spinosus* are somewhat globose, 896.8 × 867.5 µm, lack the beak near the hilum and the reticulate pattern on surface is comparatively more prominent which turns somewhat X shaped pattern towards the mid portions of the seed (Fig 5. b & d). In *A. saradhiana*, the pollen grains are spheroidal, polyaperturate, 22.46 µm across with spinulose exine sculpturing. Visible frequency of pores range from 26–30 and the number of ectexinous bodies range from 3–5 with varying degrees of fusion (Fig 5. e). In *A. spinosus*, pollen grains are spheroidal, 25.2 µm across, polyaperturate with spinulose exine sculpturing and possess 37–40 pores visible on surface and the number of ectexinous bodies

range from 3–6 with varying degrees of fusion (Fig 5. f). The protrusion of midrib beyond the leaf tip is short compared to the sharp and long protrusion found in *Amaranthus spinosus*. The stem anatomy also differs in the two taxa. The outline of stem in *A. saradhiana* is deeply ribbed with scanty chlorenchyma patches beneath. While in *A. spinosus*, the stem is more or less circular with a thick patch of hypodermal collenchyma (Fig 5.g & h). Several generations raised from seeds collected from the type locations found to retain the stable variations in subsequent generations

Surface architectural pattern of seeds, pollen morphology as well as FTIR spectral bands clearly delineates the two taxa along with other taxonomic traits. Comparative analyses of the differentiating traits of the two species are summarized in Table 1 and Fig 1, 2, 3, 4 & 5. These differentiating traits with conclusive evidences satisfy the requisites to include the variable accessions of *A. spinosus* in a new taxon, *A. saradhiana*.

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**TABLE 1.** Taxonomic discrimination of *A. saradhiana* from *A. spinosus*.

Character	<i>A. spinosus</i>	<i>A.saradhiana</i> sp.nov.
Leaf tip	extension of midrib longer	extension of midrib shorter
Stem colour	green	purple
Nature of stem	glabrous	sparsely pubescent
Shape of stem	terete	angular
Petiole colour	green	purple
Terminal spike	with spines	without spines
Number of spines per node	4	2
Length of spine	large, 10 mm long	small, 5 mm long
male-female flower ratio (in mm)	3: 6	3:4
Filament-anther ratio (in mm)	3: 1.5	2:1
Color of gynoecium	white to light green	dark green
Seed surface pattern	896.8 × 867.5µm, feebly raised ridges constituting a network in the periphery which becomes x shaped pattern in the middle portions	937.8 × 983.8µm, comparatively larger, the surface ridges are faint and not prominently organized.
Pollen morphology	25.2 µm across, frequency of visible pores range from 37–40 with 3–6 ektexinous bodies showing varying degrees of fusion	22.46 µm across, frequency of visible pores range from 26–30 with 3–5 ektexinous bodies showing varying degrees of fusion
FTIR	characteristic spectral peaks were found at 1338,1564,1641,2954,2999, 3460 (cm <sup>-1</sup> )	characteristic spectral peaks were found at 518.85, 557.43, 586.36, 619.15, 673.16, 1240.23, 1139.11, 1494.83, 1527.62, 1614.42, 1727.36, 3086.1, 3107.32, 3205.69, 3263.56, 3284.77, 3323.35, 3342.64, and 3363.86 (cm <sup>-1</sup> ). these are unique for the species



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