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Taxonomic Studies of the Genus *Mastigophora* in India

Devendra Singh[1], Meghna Paul[2*] and Titir Saha[1]
[1]Acharya Jagadish Chandra Bose Indian Botanic Garden, Howrah (West Bengal), India.
[2]Central National Herbarium, Howrah (West Bengal), India.

(Corresponding author: Meghna Paul)*
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ABSTRACT: The Indian taxa of the genus *Mastigophora* Neesare morphotaxonomically investigated and 2 species *viz. Mastigophora diclados* (Brid. ex F.Weber) Nees and *Mastigophora woodsii* (Hook.) Nees have been recognized in the bryoflora of the country.

Keywords: *Mastigophora diclados*, *Mastigophora woodsii.*

INTRODUCTION

The genus *Mastigophora* was first described by C.G.D. Nees von Esenbeck in his publication Naturgeschichte der Europäischen Lebermoose in 1838. The leafy hepatic *Mastigophora* Nees belongs to a small family Mastigophoraceae R.M. Schust is represented by only 15 species including infraspecific taxa worldwide (Söderström *et al.,* 2016). In India the genus *Mastigophora* represented by 2 species (Singh *et al.,* 2016) *viz., M. diclados* (Brid. ex F.Weber) Nees and *M. woodsii* (Hook.) Nees. The members are generally distributed in the tropics and subtropics of Southeast Asia, Africa, Pacific Islands, British Isles, British Columbia and India (Singh *et al.,* 2016). Most of the species are terrestrial growing in temperate forests and are characterized by leaves incubously arranged, leaf lobe margin distantly dentate, underleaves smaller than leaves; plants dioecious or monoecious; terminal or intercalary androecia, gynoecial branches terminal, and papillose spores with spirally thickened elaters.

In India, Mitten (1861) has reported *Sendtnera diclados*(=*Mastigophora diclados*) and *Sendtera woodsii* (=*Mastigophora woodsii*) for the first time based on the collection by JD Hooker from West Sikkim. Later, Chopra (1943) reported *M. diclados*, *M. sikkimensis* (=*M. woodsii*) based on the specimens of Punjab University Herbarium, collected from West Bengal and Sikkim. Parihar (1961-62) has also published *M. diclados* and *M. sikkimensis* (=*M. woodsii*) collected from Eastern Himalayas. Bapna and Kachroo (2000) have newly reported the occurrence of *Mastigophora woodsii* from Andaman & Nicobar Island without any specific locality and collections. Singh (2001) has also reported 3 species of *Mastigophora* based on previous published reports from Eastern Himalayas. *M. woodsii* was rediscovered from Eastern Himalayan from the state of Arunachal Pradesh (Singh & Das 2007) in India. *M. diclados* was reported by Daniels and Kariyappa (2012) for the first time from Western Ghat. Thus, previous reports are showing that the *Mastigophora* is distributed ubiquitously in biogeographical hotspots in India. During the study of liverworts and hornworts flora of Sikkim, one of the authors (DS) collected several populations of the species from different parts of Sikkim. In the present communication the genus *Mastigophora* Nees in India has been described in detail along with key and their distribution.

Key to the Indian species of the genus *Mastigophora* nom. cons.

TYPE = *Mastigophora woodsii* (Hook.) Nees

1a. Plants bipinnately branched; paraphyllia absent, cortical cells in 1(–2) layered; leaves obliquely inserted, with basal appendages, margin entire and bulging trigones…….…….....*M. diclados*

1b. Plants bi to tripinnately branched; paraphyllia present, cortical cells in 3(–4) layered; leaves transversely inserted, without appendages, margin toothed and nodulose trigones……*M. woodsii*

Taxonomic Description

Mastigophora diclados (Brid. ex F.Weber) Nees, Hist. Masc. Hep. Prodr. 56. 1815; *Mastigophora diclados* Daniels & Kariyappa, Nelumbo 54: 207. 2012. *Jungermannia diclados* Brid. ex F.Weber, Hist. Musc. Hepat. Prodr. 56. 1815. *Sendtnera diclados* (Brid. ex F.Weber.) Endl. ex Gottsche, Lindenb. & Ness, Syn. Hepat. 241. 1845. *Lepidozia diclados* (Brid. ex F.Weber) Kachroo, Kashmir J. Sci. 7: 181. 1970 (Fig. A & D).

Plants blackish to dark brown in herbarium; shoot 35–80 mm long and 1.0–1.25 mm wide including leaves, bipinnately branched, branches lateral *Frullania* type. Stem more or less semicircular in outline in transverse section, 404.0 – 454 × 282 –363µm, 16–21 cells across the diameter well differentiated; cortical cells in 1(–2) layered, 10.0 – 15.0 × 7.5 – 10.0 µm, deeply yellowish to light brown pigmented; medullary cell 15–30 × 10 – 20 µm, thick-walled, light yellowish pigmented, trigones absent Paraphyllia absent. Rhizoids not found. Leaves imbricate to rotund, obliquely spreading,

transversely inserted, concave, embracing the stem, apex subacute, margin entire, basal appendages present, 1.2–1.6 mm long and 1.8–2.3 mm wide, 2(–3)- lobed to 1/2 (–1/3) of its length, lobes asymmetrical; ventral or lateral lobes smaller, 2/3 wide of the dorsal lobe, triangular, sub-acute at apex; dorsal lobes larger than the ventral lobe, subovate–ovate, sub-acute at apex; apical leaf cells 12.5 – 22.5 × 10 –20 µm, median leaf cells 20 – 30 × 27.5 – 37.5 µm, basal leaf cells 30 – 45 × 15–30 µm, cells thin to slightly thick walled, polygonal, trigones bulging; oil bodies not seen. Leaves near the branch emergence of main shoots triangular, 1.1 – 1.2 mm long and 0.45 – 0.60 mm wide, unlobed, apex acuminate, margin entire; primary branch leaves oval, bi to trilobed with basal appendages, 0.75–0.85 long and 0.65 – 0.75 wide, secondary branch leaves 2–3 lobed with appendages at the base, 0.50 – 0.62 long and 0.45 – 0.65 wide & tertiary branch leaves bilobed without any appendage, 0.37–0.45 long and 0.30 – 0.35 mm wide. Underleaves mostly contiguous, attached on the ventral side encircling the stem, subquadrate or rotund, bilobed, margin entire with basal appendages on both sides,0.62–0.75 mm long and 0.30–0.40 mm wide; primary branch underleaves 0.50–0.62 ×0.35–0.40 mm, bilobed; secondary branch underleaves 0.45–0.55 × 0.32–0.40 mm, bilobed; tertiary branch underleaves are bilobed without appendages. Androcial and gynoecial structures are not seen.

Habitat: Saxicolous growing in moist evergreeen forest.

Distribution: India [Sikkim, Tamil Nadu (Daniels & Kariyappa 2012; Singh *et al.,* 2016)], Africa (Martin, 2009), Australia (McCarthy, 2006), China Zhu, 2006), Fiji (Söderström *et al*., 2011) [as =*M. angustisecta*], Indonesia (Söderström *et al.,* 2010), Japan (Katagiri and Furuki 2018), Malaysia (Lee *et al.,* 2022), Nepal (Pradhan & Shrestha 2021), Philippines (Tan & Engel 1986), Sri Lanka (Long & Rubasinghe 2014), Taiwan (Wang *et al.*, 2011), Thailand (Lai *et al*., 2008), Vietnam (Bakalin & Sinh 2016).

Specimen examined: India, Western Ghats, Tamil Nadu, Tirunelveli district, Pongalapparai, 8°44'34.05"N, 77°45'22.93"E, c. 1500m., 19.04.2010, K.C. Kariyappa 3650(SCCN); Agasthymalai, 8°37'7.95"N, 77°14'44.7"E, c. 1500m., 19.04.2010, K.C. Kariyappa 3652(SCCN).

Mastigophora woodsii (Hook.) Nees, Naturgesch. Eur. Leberm. 3: 95. 1835; Inoue, Bull. Natl. Sci. Mus., Tokyo, B. 14: 606. 1971; D.K. Singh & Das, Envis News Lett. 10: 1. 2007. *Jungermannia woodsii* Hook., Brit. Jungerm. 66. 1814. *Sendtnera woodsii* (Hook.) Endl., Gen. Pl. 1342. 1840. *Mastigophora sikkimensis* Steph., Sp. Hepat. 6: 368. 1922 (Fig. A-D).

Plants light green–dark green when fresh, brown to reddish brown in herbarium; shoots 40–85 mm long, 2.4–3.2 mm wide including leaves, regularly bi to tripinnately branched; branches lateral, *Frullania*-type, replacing the ventral half of the acroscopic end of the segment, thus replacing the ventral half of leaf, branches sometimes attenuate and flagelliferous. Stem more or less subcircular in outline in transverse section, 450–550 × 400–550 µm, 18–22 cells across the diameter, well differentiated; cortical cells in 3 (–4) layered, 5.0–12.5 × 2.5–7.5 µm, strongly thick-walled, deeply yellowish to light brown pigmented; medullary cells 7.5–17.5 × 7.5–15.0 µm, thick-walled, light yellowish pigmented, trigones indistinct. Paraphyllia present, pendent, usually attached at the base of leaves, 2–4 cells wide, usually branched, or sometimes simple on ultimate branches. Rhizoids few, restricted only to the flagelliform branches, hyaline. Leaves imbricate or approximate at older portion, erecto-patent to suberect, transversly inserted, obliquely spreading, concave, erect and embracing the stem, rotund–semicordate, 1.5–1.8 mm long, 1.8–2.2 mm wide (with cilia), 3 (–4)-lobed to 1/2 (–2/3) of its length, lobes asymmetrical; dorsal lobes larger, twice as wide as ventral lobe, erectopatent, semicordate–ovate, acute at apex; lateral or ventral lobes smaller, oblong-ovate, lobes divergent, ventral lobes more or less rectangular or subulate, apex and margin of lobes with unicellular teeth or short to long spiniform to ciliate teeth, cilia numerous, much crowded, erect–suberect or incurved, 3–11 cells long, 1–4 cells wide at base, usually uniseriate, sometimes biseriate at basal portion, cells of cilia 15.0 – 30.0 × 10.0 – 22.5 µm, uniformly thin-walled; apical leaf lobe cells 12.5 – 25.0 × 15.0 – 25.0 µm, thin-walled; median leaf cells 22.5 – 32.5 × 20.0–30.0 µm, thin-walled; basal leaf cells 30.0 – 55.05 × 17.5 – 27.5 µm, thin to thick-walled, trigones strongly nodulose, confluent, middle lamella distinct, cell walls often weakly conical; cuticle smooth; oil-bodies grayish, (3–) 4–5 (–7) per leaf cell, ovoid-ellipsoidal, 5.0 – 9.0 × 2.5–5.0 µm, or spherical, 3.0–4.5 µm in diameter, very finely segmented. Leaves near branch-emergence of main shoots triangular-ovate, 1.2–1.5 mm long, 1.5–1.8 mm wide at middle (with cilia), unlobed, acuminate at apex, margins with short to long spiniform to ciliate teeth; primary branch leaves semicordate, 0.85–1.1 mm long, 1.1–1.3 mm wide, slightly asymmetrical, 3-lobed to 1/2 of its length; dorsal lobes only slightly smaller than ventral lobe, margins similar to main stem leaves; secondary and tertiary branch leaves always bilobed, symmetrical with dentate margins. Underleaves usually distant or sometimes approximate, appressed to the stem, free, attached broadly encircling the stem, subquadrate or rotund, 1.0–1.2 mm long, 1.1–1.3 mm wide (with cilia), bilobed to 1/2–2/3 of its length, broadly lanceolate, acuminate at apex, margin ciliate–laciniate, cilia irregularly crowded, erect–suberect or incurved; primary branch underleaves roundish, 0.6–0.8 × 0.5–0.7 mm, bilobed to 1/2 of its length, margins similar to main stem underleaves but slightly less ciliate; secondary and tertiary branch underleaves bilobed with dentate margins.

Habitat: Terricolous and corticolous, growing in very moist and shady places on rock face covered with very thin soil or on tree trunk in association with *Plagiochila grollei*.

Distribution: India [Arunachal Pradesh, Sikkim – West and North districts, West Bengal (Singh *et al.,* 2016; Singh & Singh 2022)], China (Zhu, 2006), Nepal (Pradhan & Shrestha 2021), Taiwan (Wang *et al*., 2011), Europe (Söderström *et al*., 2007; Hodgetts *et al.,* 2020; Blockeel *et al*., 2021).

Specimen examined: India, Eastern Himalaya,

Arunachal Pradesh, Mayudia Pass, 28°14'31.35"N, 95° 55'31.04"E, c. 2655m., 16.11.2000, D.K. Singh 98147(BSD); Sikkim, West district, Gomchen, 27º26′59.2″N, 88º10′28.8″E, c. 3010m., 29.12.2011, D. Singh 52291, 52295(CAL); Tshoka, 27º26′59.9″N, 88º10′51.3″E, c. 2982m, 31.12.2011, D. Singh 54859(CAL); North district, Dobang Valley, 27º43′35.2″N, 88º45′15.2″E, c. 2920m, 21.05.2011, D. Singh 52039(CAL); 12 km from Lachung towards Katau, 27º40′53.5″N, 88º46′19.8″E, c. 3118m, 24.05.2011, D Singh 52144B, 52156(CAL).

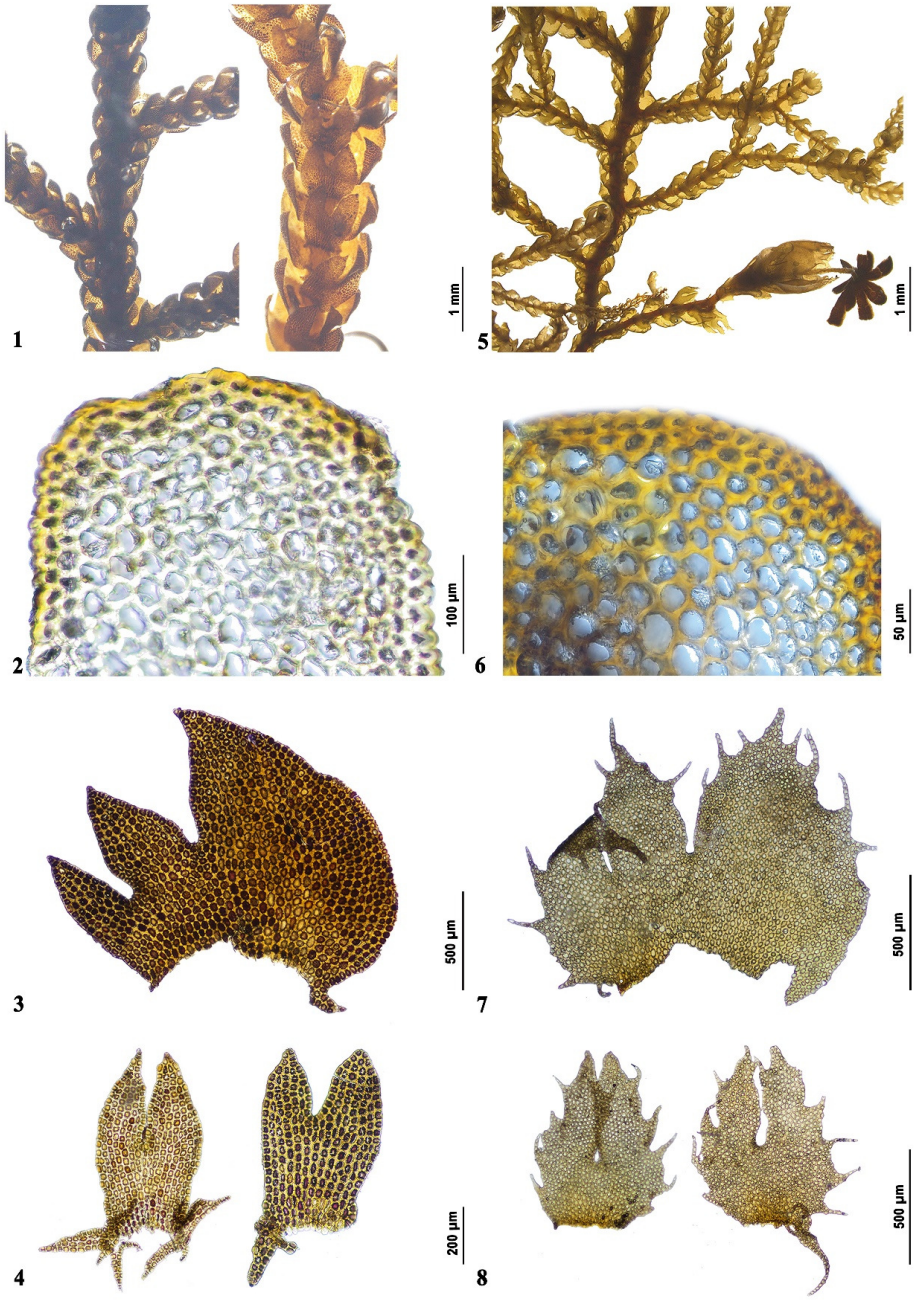

Fig. A. *Mastigophora diclados* (Brid. ex F. Weber) Nees 1. A portion of plant in ventral view and enlarged view; 2. Outline of stem T.S.; 3. Main stem leaves; 4. Underleaves of main shoot with basal appendages. *Mastigophora woodsii* (Hook.) Nees5. A portion of plant bearing a gynoecial branch; 6. Outline of stem T.S.; 7. Main stem leaves; 8. Underleaves of main shoot. [Photomicrographs 1–4 from K.C. Kariyappa 3650 (SCCN!); 5 from D.K. Singh 98147(BSD!); 6–8 from D. Singh 52039 (CAL!)]

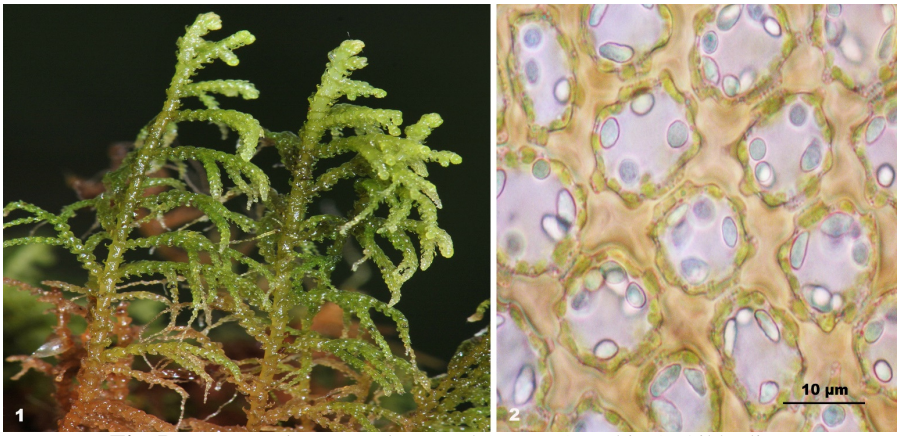

Fig. B. *Mastigophora woodsii* (Hook.) Nees 1. Habit; 2. Oil bodies.

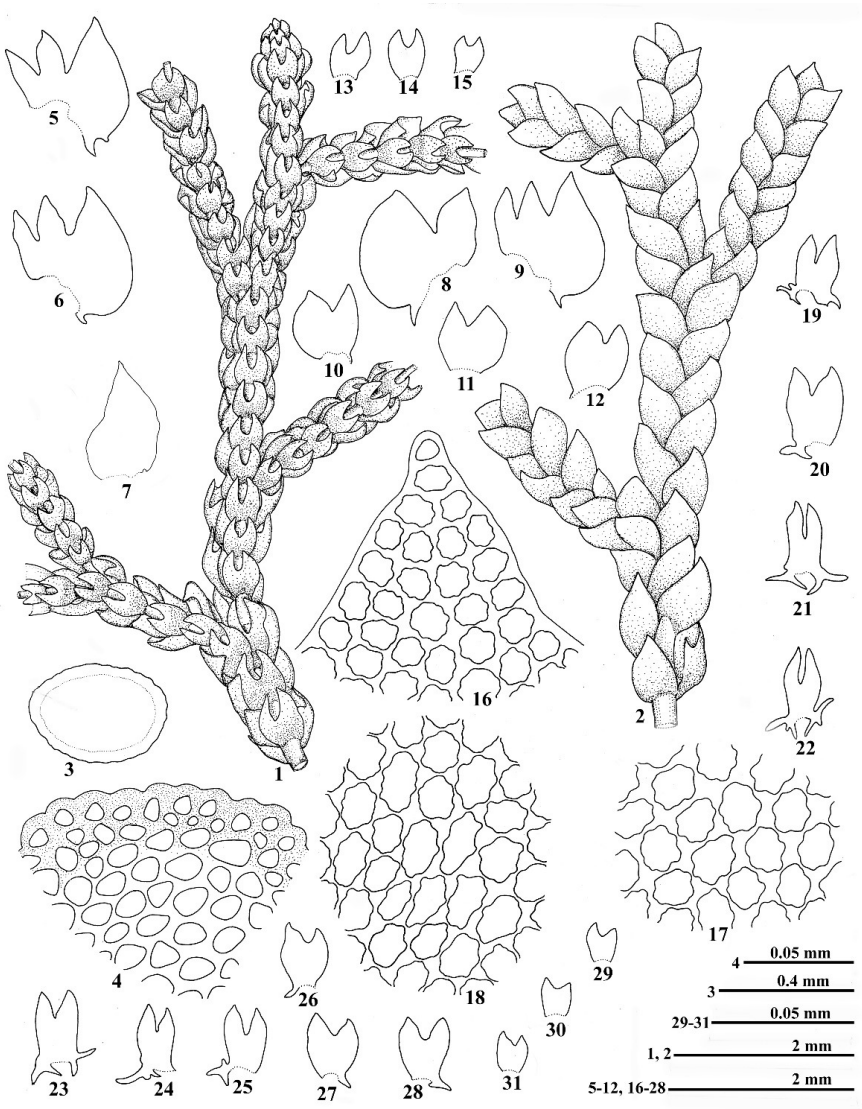

Fig. C. *Mastigophora diclados* (Brid. ex F. Weber) Nees 1. A portion of plant in ventral view; 2. The same in dorsal view; 3. A portion of transverse section of stem; 4. A portion of the same enlarged; 5,6. Main stem leaves; 7. Branch emergent leaf of main stem; 8,9. Leaves of primary branch; 10–12. Leaves of secondary branch; 13–15. Leaves of tertiary branch; 16. Apical leaf cells; 17. Median leaf cells; 18. Basal leaf cells; 19–21. Underleaves of main shoot with basal appendages; 22–24. Underleaves of primary branch; 25–27. Underleaves of secondary branch; 28–30. Underleaves of tertiary branch; (All figures drawn from K.C. Kariyappa 3650).

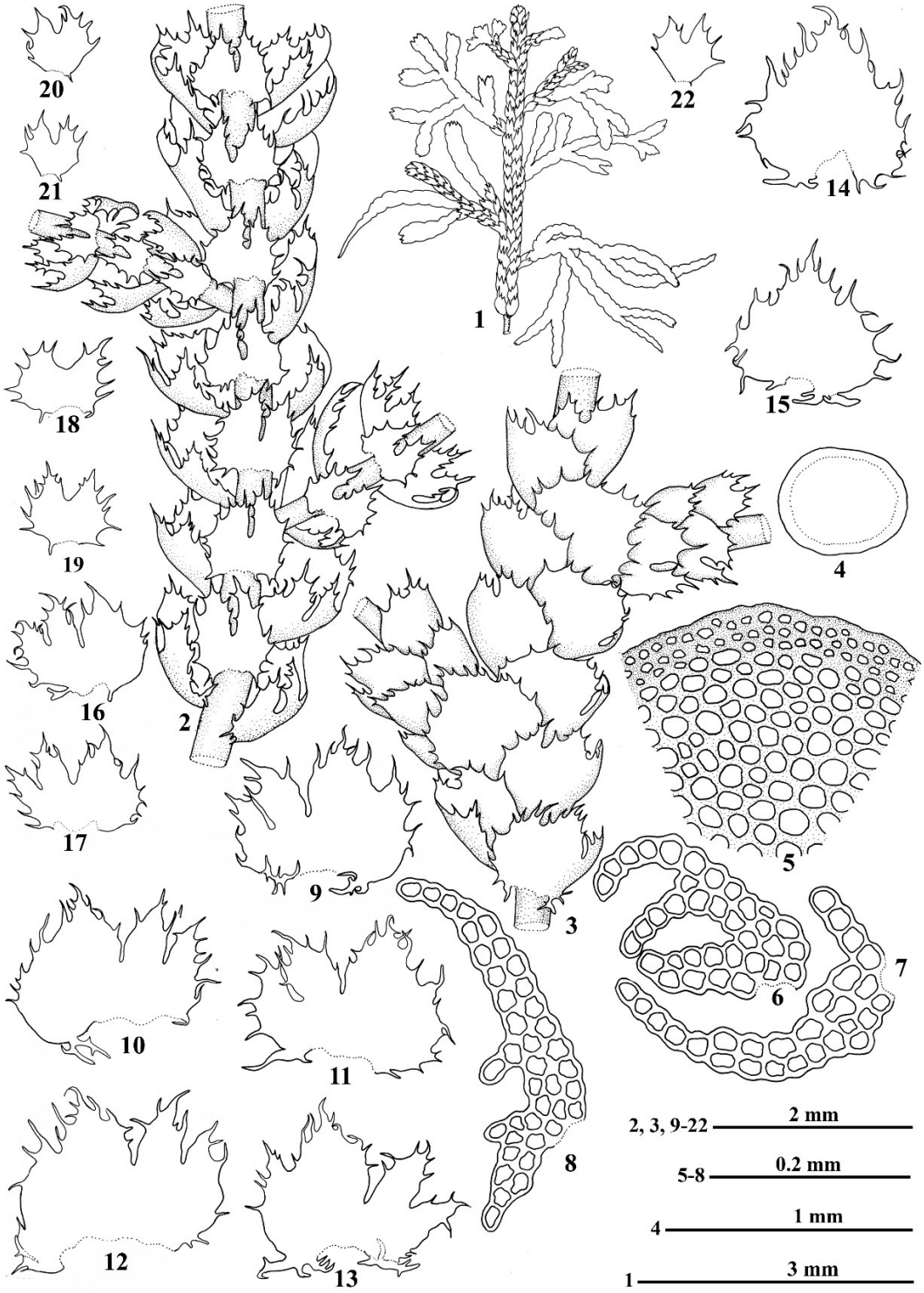

Fig. D. *Mastigophora woodsii* (Hook.) Nees 1. Habit (schematic representation); 2. A portion of plant in ventral view; 3. A portion of plant in dorsal view; 4. A portion of transverse section of stem.; 5. A portion of the same enlarged; 6–8. Stem paraphyllia; 9–19. Leaves [9–13 from main stem, 14,15 from main stem branch emergent, 16,17 from primary branch, 18,19 from secondary branch, 20–22. from tertiary branch (All figures drawn from D. Singh 52039)].

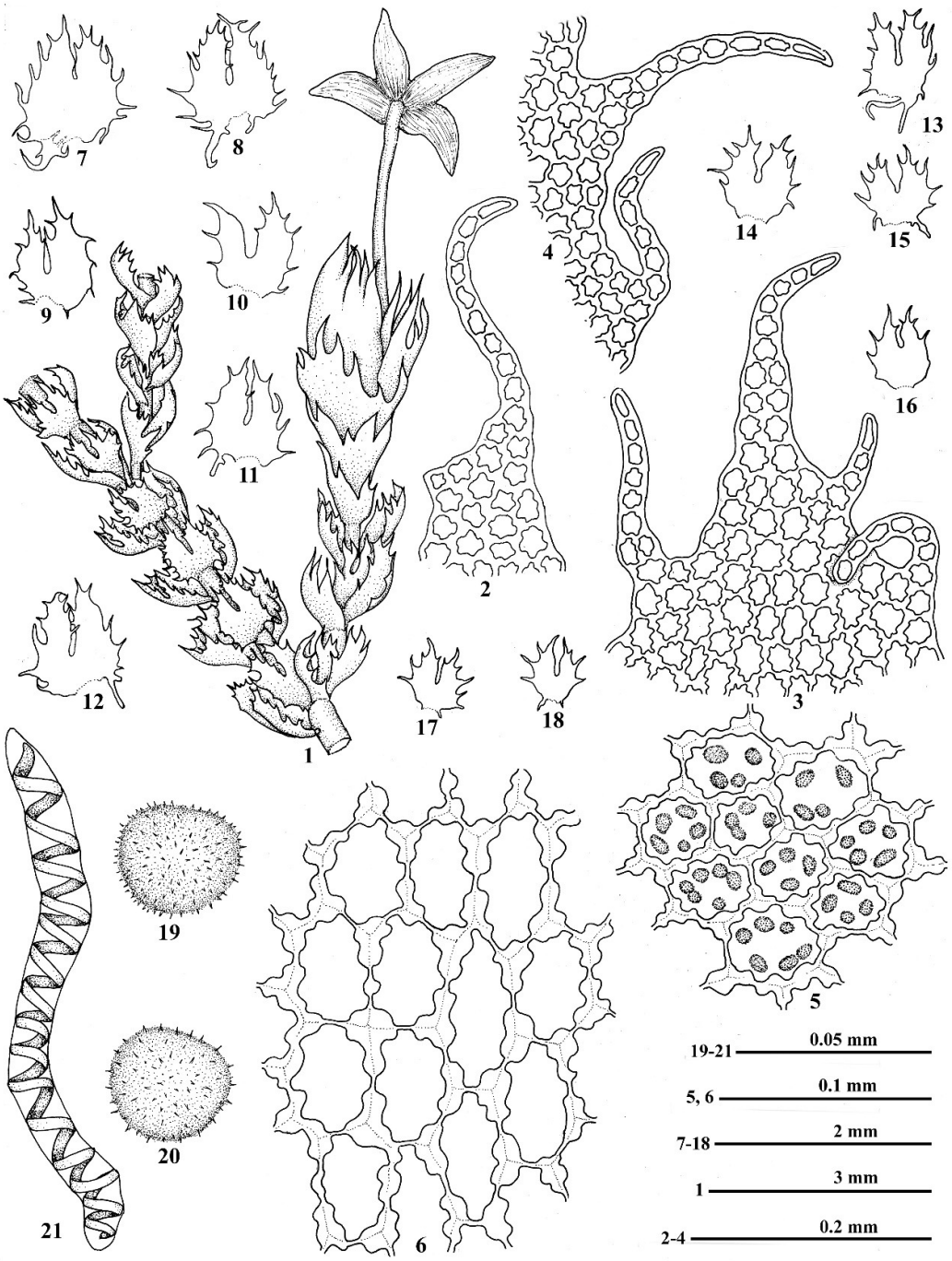

Fig. E. *Mastigophora woodsii* (Hook.) Nees 1. A portion of plant bearing a gynoecial branch; 2–4. Apical leaf lobes cells; 5. Median leaf lobes cells showing oil bodies; 6. Basal leaf lobes cells; 7–18. Underleaves (7–12 from main stem, 13, 14 from primary branch, 15,16 from secondary branch, 17, 18 from tertiary branch [(figures 1, 20–21 drawn from D.K. Singh 98147(BSD), 4 from D. Singh 52144B (CAL), others from D. Singh 520039)].

Fig. F. Map showing the distribution pattern of the genus *Mastigophora* Nees in India.

CONCLUSIONS

The genus *Mastigophora* represented byn15 species including infra specific taxa are distributed globally. In the present communication the taxonomic status and distribution of 2 species *viz. M. diclados* and *M. woodsii* in India have been discussed. Both the species are distributed widely around the world. While the distribution of *M. diclados* is more frequent and common than *M. woodsii*. *M. diclados* is pantropically distributed in the countries like Africa, Australia, China, Indonesia, India, Japan, Vietnam, Philippines, Hawaii whereas *M. woodsii* is restricted only in India, Nepal China and few parts of Europe.

FUTURE SCOPE

Bryophytes play the key role and have great contributions to global cycles in different ecosystems and changing climate affects. Some of the plant species are also heavy metal accumulator.

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Conflict of Interest. None.

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