RESEARCH COMMUNICATION

A study on some taxa of family Mniaceae (Bryophyta) in Darjeeling (West Bengal), India

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ABSTRACT
During study on the family Mniaceae in Darjeeling and its neighbouring areas, three genera and six species (Mnium lycopodioides, Orthomnion bryoides, Plagiomnium acutum, P. confertidens, P. rhynchophorum and P. succulentum) have been identified. Of these Plagiomnium acutum is reported here for the first time from eastern Himalaya. A detailed morpho-taxonomic account of these species with their current status and a key to all the taxa of family Mniaceae in Darjeeling is provided here.

Introduction
Darjeeling is located in West Bengal, surrounded by Sikkim in North, Bihar in South, Kalimpong in East and Nepal in West, at an elevation of 6700 ft. The humidity usually ranges between 72 to 96% and annual temperature ranges between 2 to 19°C with 309.2 cm annual precipitation. Darjeeling has a temperate climate and the vegetation comprises of Sal, oak, semi evergreen temperate and alpine forests. The members of family Mniaceae Schwägr. are distributed all over the world in temperate regions where they grow in moist and shady places on rocks and bark of trees. The family has been treated by several authors from time to time and only later, a reasonable criterion for demarcation of different genera has been developed (1). Family Mniaceae on worldwide basis contains nine genera and about 75 infra-generic taxa but in India five genera (Mnium Hedw., Orthomnion Wils., Plagiomnium T. J. Kop., Pseudobryum (Kindb.) T. J. Kop. and Rhizommum T. J. Kop.) and about 27 taxa are present (2-7).

As far as diversity of family Mniaceae in Darjeeling is concerned, earlier researchers had documented 18 taxa (4-6, 8-12). Of these, 14 taxa are recognized except Mnium laevinerve Card. which is synonymised under M. lycopodioides Schwægr., M. undulatum Hedw. is not found in India (6), M. marginatum (With.) P. Beauv. var. riparium and M. pseudopunctatum Bruch & Schimp. earlier described now considered as Mnium lycopodioides and Rhizommum nudum (Britt. & Williams) T. J. Kop. respectively (4, 6, 13). During the present study, out of these 14, six taxa have encountered including Plagiomnium acutum (Lindh.) T. J. Kop. which is recorded here for the first time from eastern Himalaya (4-7). The members of this family are remarkable for being almost confined to moist and shady places and having significant diagnostic characters like erect and prostrate habit, smooth or serrated leaf margin, teeth on leaves double or single or none, the anatomy of costa as well as border and pattern of leaf cells, pitted or not (1). At present, no up to date information is available on the diversity in family Mniaceae in India and hence a taxonomic revision is needed.

Materials and Methods
The present study is based upon the specimens collected from different areas of Darjeeling. The specimens have been deposited in the Bryophyte Herbarium, National Botanical Research Institute, Lucknow (LWG). Plants were soaked in water to regain their natural form and then identified with the help of binocular and Leica microscope. Plants were also photographed for easy identification of species.

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Results

Taxonomic treatment

Key to the taxa of family Mniaceae in Darjeeling

1a. Leaves serrated, costa with stereids..............2
1b. Leaves entire, costa without stereids..........11

2a. Plants reddish, erect, without plagiotropic shoots, marginal teeth of leaf double (paired), costa with two stereid bands........................................3
2b. Plants green to brown, with plagiotropic shoots, marginal teeth of leaf single, costa with one stereid band...................................................4

Fig. 1. (A–O). *Mnium lycopodioides* Schwager. (LWG 225364C) A–H: A. Plant habit; B–D. Leaves; E. Leaf apex; F. Leaf apical cell; G. Leaf basal cells; H. Leaf median cells. *Orthomnion bryoides* (Griffith) Nork. (LWG 225495B) I–O: I. Plant habit; J, K. Leaves; L. Leaf apex; M. Leaf apical cells; N. Leaf median cells; O. Leaf basal cells.
3a. Leaves ovate-lanceolate to broadly elliptic, laminal cells heterogenous (22.5–30 µm) ...........................................Mnium lycopodiodes*

3b. Leaves elliptic to narrowly elliptic, laminal cells homogenous (11.25–18.75 µm)...............................

            ..................................................Mnium thomsonii

4a. Leaf margin toothed up to middle..........................Plagiomnium acutum*

4b. Leaf margin toothed up to base.........................5

5a. Leaf marginal teeth long and sharp....................6

5b. Leaf marginal teeth small and blunt...............7

Fig. 2. (A–P). Plagiomnium acutum (Lindb.) T. J. Kop. (LWG 223977A) A–G: A. Plant habit; B, C. Leaves; D. Leaf apex; E. Leaf apical cells; F. Leaf median cells; G. Leaf basal cells. Plagiomnium confertidens (Lindb. & Arnell) T. J. Kop. (LWG 223364C); H–P: H. I. Plant habit; J–L. Leaves; M. Leaf apex; N. Leaf apical cells; O. Leaf median cells; P. Leaf basal cells.
6a. Leaves oblong, transversely undulated.................................\textit{Plagiomnium confertidens}\textsuperscript{*}

6b. Leaves elliptic to broadly elliptical, not undulated.........................\textit{Plagiomnium medium}

7a. Leaves with indistinct border, laminal cells much larger..................\textit{Plagiomnium succulentum}\textsuperscript{*}

7b. Leaves with distinct border, laminal cells smaller.................................8

8a. Leaf bases not decurrent........................................\textit{Plagiomnium rostratum}

8b. Leaf bases decurrent .................................................9

9a. Leaves with undifferentiated juxta costal cells.................................\textit{Plagiomnium integrum}
9b. Leaves with differentiated juxtacostal cells..............10

10a. Plants synoicous.........................................

*Plagiomnium rynchophorum* subsp. rynchophorum*

10b. Plants dioecious........................................

*Plagiomnium rynchophorum* subsp. maximoviczii

11a. Leaf margin with undifferentiated border, costa single and branched..................................................Pseudobryum cinclidiodes

11b. Leaf margin with differentiated border, costa single and unbranched...............................................12

12a. Plants green to brownish, with plagiotropic shoots.................................................................13

12b. Plants reddish, erect, without plagiotropic shoots.................................................................................14

13a. Leaf border strong, throughout the leaf length......................Orthomnion bryoides*

13b. Leaf border weak, restricted to base, hardly reaching till middle........Orthomnion noguchii

14a. Leaves broadly obovate, leaf apex apiculate, laminar cells large.....Rhizomnium horikawae

14b. Leaves elliptical, leaf apex not apiculate, laminar cells small..............Rhizomnium striatum

(*dealt in the present study)


Description

Plants green to reddish brown, erect, leaves closely arranged at apex, 2.5–3 cm long. Leaves ovate lanceolate, 2.5–3.0 × 1.8–2.0 mm, leaf base long decurrent, apex acute, border 2–3 layered, teeth double (paired), costa excurrent, 100–120 µm wide at base, leaf in cross section shows both dorsal and ventral stereid bands. Leaf apical cells short quadrate to isodiametric, 8–20 × 8–20 µm, middle cells usually isodiametric, thick walled, pitted, incrassate, corner thickening present but not prominent, 37–49 × 19–26 µm, basal cells rectangular, 60–100 × 28–40 µm (Fig. 1. I–O).

Specimens examined: India, West Bengal, Darjeeling, Tiger Hill, ca 2500 m, epiphytic, 19.04.1965, S. Chandra 202180A (LWG); on way to Munngoo, ca 1757 m, epiphytic, 26.09.2002, A. K. Asthana and V. Sahu 224129A (LWG); on way to Tonglu, ca 2489 m, epiphytic, 02.11.2003, A. K. Asthana and V. Sahu 224346J (LWG); on way to Teesta, ca 1696 m, on stone rock, 24.04.1965, S. Chandra 202180A (LWG); on way to Phalut from Sandakphu, ca 3636 m, on soil covered rock, 06.11.2003, A. K. Asthana and V. Sahu 225380B, 225385A (LWG).

Distribution: India: Eastern Himalaya (Arunchal Pradesh, Sikkim, West Bengal–Darjeeling), Western Himalaya (Garhwal); Afghanistan, Bhutan, China, Japan, Korea, Nepal, Philippines, Taiwan and Vietnam (3-7).

Other specimens studied: Musci Japonici Exsc. 67 (as *Mnium laevinerve* Card.), 231 (as *Mnium thomsonii* Schimp.) 433.

*Orthomnion* Wils. in Mitt., Kew J. Bot. 9: 368 (1857).


Description

Plants yellowish green, creeping, reddish brown rhizoids present all over the stem surface, up to 4 cm long. Leaves elliptical to narrowly elliptical, 3–4 × 1.5–2 mm, leaf base not decurrent, apex apiculate, border 3 layered, entire, recurved and wavy when moist, costa narrow percurrent, guide cells not visible, typical stereids lacking in the cross section of leaf. Leaf apical cells elongated hexagonal, 36–48 × 28–40 µm, middle cells elongated hexagonal, thin walled, pitted, incrassate, corner thickening present but not prominent, 37–49 × 19–26 µm, basal cells rectangular, 60–100 × 28–40 µm (Fig. 1. I–O).

Specimens examined: India, West Bengal, Darjeeling, Tiger Hill, ca 2500 m, epiphytic, 19.04.1965, S. Chandra 202180A (LWG); on way to Munngoo, ca 1757 m, epiphytic, 26.09.2002, A. K. Asthana and V. Sahu 224129A (LWG); on way to Tonglu, ca 2489 m, epiphytic, 02.11.2003, A. K. Asthana and V. Sahu 224346J (LWG); on way to Teesta, ca 1696 m, on stone rock, 24.04.1965, S. Chandra 202180A (LWG); on way to Phalut from Sandakphu, ca 3636 m, on soil covered rock, 06.11.2003, A. K. Asthana and V. Sahu 225380B, 225385A (LWG).


Other specimens studied: Isotype (232004 H-SOL).


Description

Plants yellowish green, sub erect to prostrate, upper leaves more crowded, 1.5–3 cm long. Leaves contiguous to distantly arranged, ovate spatulate, 2.5–4.0 × 1.2–1.8 mm, leaf base long decurrent, apex acute, border 3–4 layered, teeth sharp, projecting, 1–2 celled, dentate up to middle, costa reddish brown, excurrent, 120–160 µm wide at base, leaf in cross section shows only dorsal stereid band (sometimes both dorsal and ventral stereid bands present). Leaf apical cells quadrato to isodiamic, 12–24 × 8–16 µm, middle cells usually isodiamic, thick walled, corner thickening absent, 15–19 × 15–23 µm, basal cells rectangular, 8–28 × 12–16 µm (Fig. 2. A–G).
Specimens examined: India, West Bengal, Darjeeling, Lloyd Botanical Garden, ca 1818 m, on soil covered rock, 22.09.2002, A. K. Asthana and V. Sahu 223962B, 223966B, 223971B, 223977A (LWG); on way to Sandakphu, ca 3091 m, on soil, 05.11.2003, A. K. Asthana and V. Sahu 225366A (LWG).

Distribution: India: Eastern Himalaya (West Bengal–Darjeeling), Western Himalaya (Kashmir); Bhutan, China, Japan, Mongolia, Nepal, Russia, Vietnam (4-7).

Other specimens studied: Musci Japonici Exsc. 68, 375 (as Mnium trichomanes), Holotype (232001 H-SOL).


Description
Plants yellowish green, robust, erect, dendroid with subterranean stolons, branched, 4–7 cm long. Leaves curled when dry, oblong, elliptical to lingulate, 5–8 x 2–3 mm, leaf base long decurrent, apex acute, border 2–4 layered, teeth blunt 1–2 celled, dentate up to base, costa excurrent, 240–260 µm wide at base, leaf in cross section shows only dorsal stereid band. Leaf apical cells short quadrate to isodiametric, 8–12 x 8 µm, middle cells rectangular, slightly pitted, thick walled, corner thickening prominent, 33–38 x 11–15 µm, basal cells rhomboidal hexagonal 20–40 x 12–16 µm (Fig. 2. H–P).

Specimens examined: India, West Bengal, Darjeeling, Forest Rest House, ca 2000 m, on soil, 16.04.1965, S. Chandra 202023A (LWG); Tonglu–Sandakphu, ca 2500 m, epiphytic, 25.04.1965, S. Chandra 202322D, 202342A (LWG); Sandakphu–Phalut, ca 3500 m, on soil, 26.04.1965, S. Chandra 202379C, 202400D (LWG); Kalipokhri, ca 2909 m, on soil covered rock, 05.11.2003, A. K. Asthana and V. Sahu 225357G (LWG); on way to Sandakphu, ca 3091 m, on soil covered rock, 05.11.2003, A. K. Asthana and V. Sahu 225364C, 225376D (LWG).

Distribution: India: Eastern Himalaya (West Bengal–Darjeeling), Meghalaya–Khasia Hills), South India (Nilgiri hills); Borneo, Bhutan, China, Indonesia, Nepal, North Vietnam, Myanmar, Philippines, Sabah, Sri Lanka, Taiwan, Thailand (4-8).


Description
Plants yellowish green, prostrate, branched, 3–4 cm long. Leaves open when dry, oblong ovate to broadly elliptic, 8–10 x 6–7 mm, leaf base not decurrent, apex obtuse to acuminate, entire or minutely dentate, teeth blunt, 1–2 celled, costa weak, ending below apex, 120–140 µm wide at base, leaf in cross section shows only dorsal stereid band. Leaf apical cells hexagonal, 48–88 x 40–48 µm, middle cells much larger elongated hexagonal, thin walled, corner thickening absent, 101–128 x 37–41 µm, basal cells rectangular, 60–88 x 32–44 µm (Fig. 3.I–N).

Specimens examined: India, West Bengal, Darjeeling, on way to Manebhanjang, ca 2000 m, epiphytic, 17.04.1965, S. Chandra 202050A (LWG).

Distribution: India: Eastern Himalaya (Assam, West Bengal–Darjeeling (Kurseong, Mungpoo), Meghalaya–Khasia Hills); Bonin Islands, Bhutan, China, Japan, Nepal, North Borneo, Indonesia, Malaysia, Myanmar, Korea, North Vietnam, Philippines, Taiwan, Thailand (4-8).

Other specimens studied: Musci Japonici Exsc. 230.

Discussion
The recent study reveals the occurrence of six taxa of family Mnioceae in Darjeeling (Fig. 4) belonging to three genera Mnium, Plagiomnium and Orthomnion. Genera Mnium and Orthomnion are represented by
single species each while Plagiomnium is represented by four species. Mnium lycopodiodes Schwaegr. is remarkably different from Orthomnion and Plagiomnium in having red colour on stem, paired tooth, two steleid bands in cross section of costa, whereas Orthomnion bryoides (Griffith) Nork. morphologically characterised by plagiotropic shoots, entire leaf margin, costa ceasing below tip or excurrent, well developed leaf border and no steleid band in cross section of costa. Plagiomnium acutum (Lindb.) T. J. Kop. comes under the section Plagiomnium T. J. Kop. of genus Plagiomnium and can easily be differentiated from all other species in

Plagiomnium conforptidens (Lindb. & Arnell) T. J. Kop. belongs to section Undulata (Kindb.) T. J. Kop., having oblong leaves toothed up to base. Although Plagiomnium succulentum (Mitt.) T. J. Kop. and Plagiomnium rhynchophorum (Hook.) T. J. Kop. belong to same section Rostrata (Kindb.) T. J. Kop., but former species comprises of not decurrent leaf bases, much larger laminar cells, costa vanishing below tip whereas the latter has decurrent leaf bases, smaller laminar cells and excurrent costa.

According to earlier published literatures (4-6), all the 18 species described and enlisted by them were treated in genus Mnium Hedw. which are now placed in distinct genera with 14 species (1, 3, 6, 8, 13). During the present study, it was found that some species described earlier have been synonymized or their status is changed. This work is based on the collections made from selected 10 localities of Darjeeling and specimens were deposited in CSIR-National Botanical Research Institute, Lucknow (LWG). After critical and comparative study with authentic Herbarium specimens obtained on loan from Finnish Museum of Natural History, Botanical Museum (H) and recent literature, the updated number of taxa in Darjeeling is now 15 with Plagiomnium acutum (Lindb.) T. J. Kop. as new report to eastern Himalaya.

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Competing interest
Authors do not have any conflict of interest to declare.

Authors’ contribution
The first and second authors identified the specimens and prepared the manuscript, photo plates and map of the study area. The second and third author carried out field explorations to Darjeeling and neighbouring areas and collected the plant specimens. The third and corresponding authors finalized and investigated all the details, checked the manuscript and submitted for publication.

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