

***Monosolenium tenerum* Griff. (Marchantiopsida, Monosoleniaceae) in Nepal**

Nirmala PRADHAN^a, David G. LONG^{b*} and Sanu Devi JOSHI^a

^aCentral Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal

^bRoyal Botanic Garden, Edinburgh EH3 5LR, UK

(Received 6 February 2007, Accepted 12 February 2007)

Abstract – The monospecific complex thalloid liverwort genus *Monosolenium* Griff. is newly reported from Nepal, from the Royal Bardia National Park in south-west Nepal. A summary of earlier studies on the genus is given together with a description and illustration of the Nepalese material, notes on its ecology and a short assessment of its biogeography. In the wild, the species is a coloniser of moist soil in subtropical countries.

Marchantiopsida / *Monosolenium* / Himalaya / Nepal / Royal Bardia National Park

INTRODUCTION

The complex thalloid liverwort genus *Monosolenium*, though known for a long number of years, has only received occasional attention in the bryological literature, with recent contributions to its history provided by Kapila & Kumar (1995) and Gradstein *et al.* (2003). The genus and its single species *M. tenerum* were first described by William Griffith (1849) in his posthumous publications, based on specimens he had collected in Assam, north-east India. Stephani (1898–1900), however, did not recognise the genus and treated it as a synonym of *Cyathodium* (Cyathodiaceae). Goebel (1910) acquired new living material which he cultured at the Munich Botanic Garden in Germany where it was discovered growing on soil imported with tea plants received from the German Consulate in Canton [= Guangzhou, Guangdong Province, China]. From this material he made a detailed morphological study, confirming its distinct identity. He used the relatively simple gametophytic morphology of *Monosolenium* in developing a hypothesis of reduction within Marchantiales, with carpocephalate genera such as *Marchantia* considered to be more ancestral than simpler genera such as *Monosolenium* which he hypothesized was derived by reduction from a *Dumortiera*-like ancestor (Goebel, 1910; Schuster, 1992). Recent studies using molecular phylogenetics would appear to support this hypothesis (Boisselier-Dubayle *et al.*, 2002; Forrest *et al.*, 2006). A further report, from a plant nursery in Oakland, California (Campbell, 1923) was also considered to be an accidental introduction from Asia.

*. Correspondence and reprints: d.long@rbge.ac.uk

Subsequently the genus has been reported relatively rarely in new localities in east Asia, particularly from Japan, China (Sichuan, Taiwan) and India (Manipur) (Hattori, 1942, 1944, 1951, 1952; Kashyap, 1924; Kamimura, 1952; Chen, 1955; Yang, 1965; Shin, 1968). Detailed descriptions and illustrations have been provided by Inoue (1966, 1976), Bischler (1998) and others (see below). Horikawa (1934) re-described *Monosolenium tenerum* as a new monospecific genus *Dumortieropsis liukiensis* Horik. from the Ryukyu Islands of southern Japan; these names were synonymized by Hattori (1944). Inoue (1966) treated the genus as a new family Monosoleniaceae, which he compared with *Dumortiera* and *Monoclea* and confirmed its distinctness from both; later he (Inoue, 1976) placed it in a new Suborder Monosoleniineae Inoue within Order Marchantiales. Miller *et al.* (1983) considered an earlier record from Hawaii as doubtful; he also reported the genus from several new parts of the world: Sikkim, Burma, Thailand, Tonkin, Java and central and west Africa but for none of these were literature sources or specimens cited, and all must be treated as doubtful records. Kapila & Kumar (1995) published the first substantiated record from the Himalayan mountains, from Himachal Pradesh, north-west India and Singh & Singh (2007) have reported a new locality discovered in 2002 at Dehra Dun in Uttaranchal, which is the nearest known locality to Nepal. Hence this genus remains known from comparatively few isolated localities in eastern Asia.

In recent years *Monosolenium* has become an important aquarium plant (Gradstein *et al.*, 2003) and is now readily available for purchase; previously it was erroneously sold under the name *Pellia endiviifolia*. It is also cultivated in the Botanic Garden in Göttingen in Germany (Gradstein *et al.*, 2003). In Japan it has been associated with human habitation (Schuster, 1992) and it is possible that its occurrence in some countries is a result of accidental dispersal by humans.

The discovery of *Monosolenium* in Nepal was made in January 2001 by the first author during a survey of the bryophytes of the western lowlands of Nepal which took place from January 2001 to June 2003. This included the Royal Bardia National Park where no bryological exploration had taken place before.

MATERIALS AND METHODS

In the Nepalese locality specimens were collected into paper packets and field notes recorded. For morphological study, thalli were soaked in water for a few hours and observed by light microscopy; a description was prepared from the Nepalese material and illustrations drawn freehand by NP. Identification was confirmed by DGL.

DESCRIPTION OF NEPALESE MATERIAL

Monosolenium tenerum Griff. *Notulae ad Plantas Asiaticas* II: 341 (1849); Icon. Plant. Asiat. II, plate 75B fig. 1 (1849).

Monosolenium tenerum has been described and illustrated in detail by several authors: Goebel (1910), Horikawa (1934, as *Dumortieropsis liukiensis*), Yang (1965), Inoue (1966, 1976), Kapila & Kumar (1995), Bischler (1998) and Gradstein *et al.* (2003).

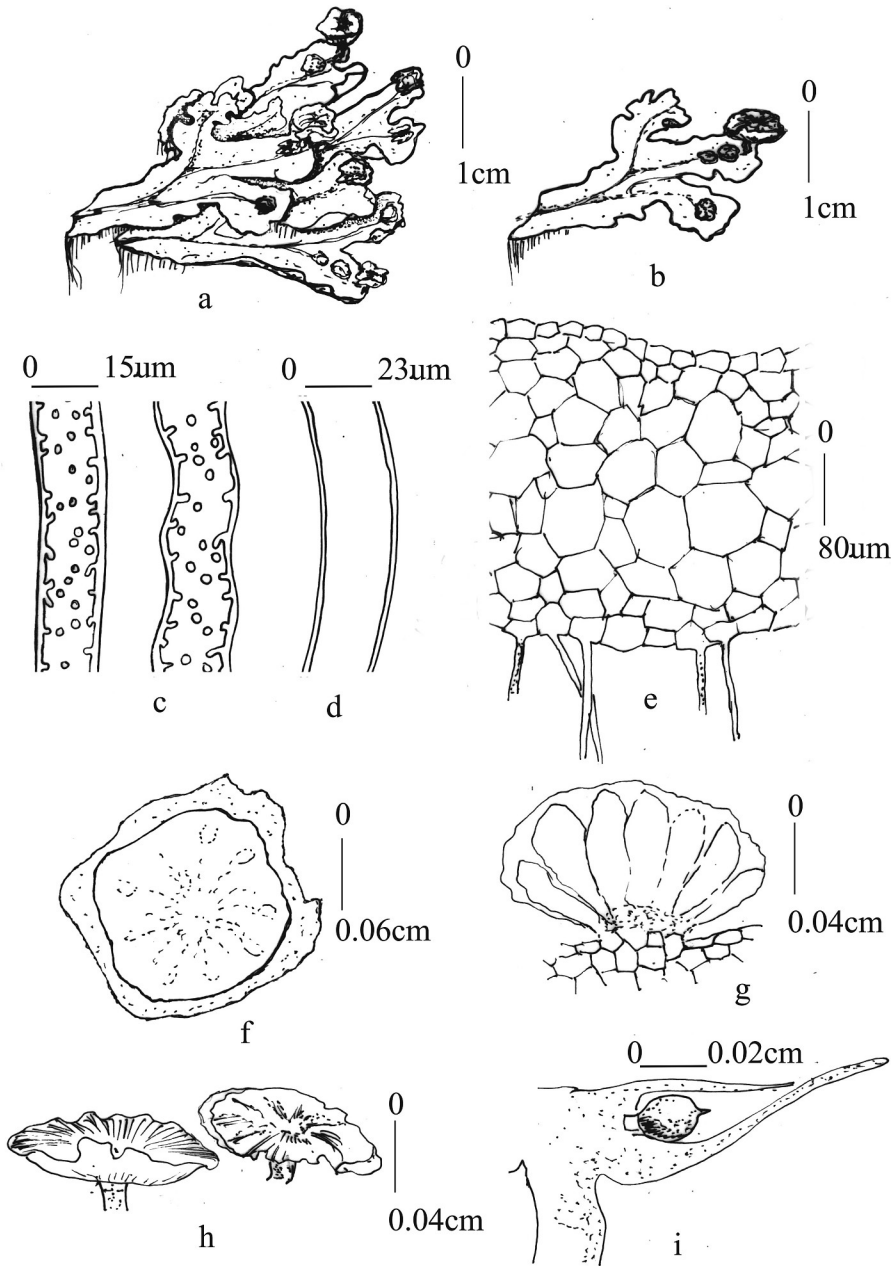


Fig. 1. **a**, habit of fertile plant; **b**, fertile thallus showing a flat-topped carpocephalum and androecial cushions; **c**, part of two pegged rhizoids; **d**, part of single smooth rhizoid; **e**, portion of t.s. of thallus; **f**, androecial cushion in dorsal view; **g**, t.s. of androecial cushion; **h**, two detached carpocephala; **i**, t.s. of part of carpocephalum with developing sporophyte. Drawn by N.P. from Nepalese material.

In Nepal (Fig. 1) it may be recognised by its thin, dark green, dichotomously branched thalli up to 3.5 cm long and 5-8 mm broad with a thickened midrib and thinner semi-translucent wings with wavy margins. The dorsal surface is uniformly smooth with no air pores or reticulations. In transverse section the thallus is relatively undifferentiated, with a distinct upper epidermal layer composed of cells containing chloroplasts; amongst these are scattered oil-cells each containing a single large oil-body. The inner tissue lacks oil-cells and the cells contain few chloroplasts. Air chambers are absent. The ventral epidermis bears two rows of small hyaline ventral scales mixed with both smooth (up to 23 μm diameter) and pegged (12-15 μm diameter) rhizoids. Specialised vegetative reproductive structures are absent.

The plants are monoicous, bearing sporophytes on stalked carpocephala arising from the apical notch of the thallus and androecia in sessile dorsal cushions borne directly on the thallus proximal to the base of the receptacle stalk. The female receptacle is disk-shaped, 1.8-2 mm diameter, with a shallowly-lobed undulate margin, borne on a short stalk 1-2 mm long, with two rhizoid furrows. Sporophytes are borne in bivalved involucre on the lower surface of the carpocephalum; the capsule dehisces by irregular valves. The spores in Nepalese material are immature; they are reported (Kapila & Kumar, 1995) as often remaining united in tetrads, reticulate, 37-43 μm in diameter; elaters are without spiral thickened bands (Kapila & Kumar, 1995).

In the field *Monosolenium* is more likely to be confused with simple thalloid liverworts (Class Jungermanniopsida, Orders Pelliales and Metzgeriales) such as *Calycularia* (Calyculariaceae), *Pellia* (Pelliaceae) and *Aneura* (Aneuraceae), than with other complex thalloid genera (Class Marchantiopsida). *Monosolenium* differs from all simple thalloid liverworts in the presence of pegged rhizoids, specialised epidermal oil-cells and stalked carpocephala. It differs from most complex thalloid liverworts in the absence of air chambers and air pores in the thalli and carpocephala; the only complex thalloid genera in the Himalaya likely to cause confusion through lack of air pores and air chambers are *Blasia* (Blasiaceae) and *Dumortiera* (Dumortieraceae). Both of these differ in the lack of conspicuous oil-cells in the epidermis. *Blasia* can additionally be distinguished by bearing abundant multicellular gemmae in flask-shaped receptacles on the thallus and having only smooth rhizoids; *Dumortiera* can also be distinguished by its larger size (thalli up to 20 mm wide), the presence of numerous bristles on the ventral surface and margins of the thallus and on receptacles, and by having both antheridia and sporophytes on stalked receptacles, and a tubular involucre surrounding the developing sporophyte.

Specimen examined: West Nepal, Bardia District, Betahani, Royal Bardia National Park, 28° 27.73'N and 87° 14.68'E, 120 m, on moist shaded soil along stream, 18 i 2001, Pradhan et al. NGS 142 (Herb. Nat. Hist. Mus. Kathmandu, E).

ECOLOGY AND DISTRIBUTION

In the Royal Bardia National Park *Monosolenium* was discovered growing on moist shaded soil along a forest stream in mixed deciduous forest dominated by the trees *Shorea robusta* Gaertn.f., *Dalbergia sissoo* DC. and *Bauhinia vahlii* Wight & Arn. The plants were shaded by ferns such as *Sphaerostephanos appendiculatus* (Bl.) Holtt. and *Dryopteris cochleata* (D. Don) C. Chr. It was not found elsewhere in the Park.

The Royal Bardia National Park covers 968 square kilometres and is located at an elevation of 110 to 1440 m from 28° 17' to 18° 40' N and 81° 12' to 81° 43' E in the mid-west lowland “terai” region of Nepal. The topography includes two major rivers (Karnali and Babai Rivers) with riverine flood plains and includes low ridges and foothills of the Himalaya. Deciduous subtropical *Shorea robusta* Gaertn.f./ *Terminalia alata* Roth forest is the dominant type and covers about 39% of the Park area. Other parts of the Park are dominated by grasslands or have been cleared in the past for agriculture. The Park is a very valuable protected area for its rich biodiversity, not only the indigenous forests and terai vegetation, but also rare mammals, birds and invertebrates. To date, 36 species of bryophytes have been found during the survey, including both terrestrial and epiphytic mosses and liverworts. Other Marchantiales recorded include *Asterella wallichiana* (Lehm. & Lindenb.) Grolle and *Plagiochasma pterospermum* C. Massal. (*P. articulatum* Kashyap).

Relatively little appears to have been published about the natural habitat of *Monosolenium*, reports include wet and moist shaded soil (Horikawa, 1934; Inoue 1976; Kapila & Kumar, 1995) and calcareous mud in an area of limestone caves in Japan (Shin, 1968). However, there is more information on ecology in man-made habitats, as in a garden in Manipur (Kashyap, 1924), and in glasshouses in Taiwan (Yang, 1965) and Göttingen in Germany (Gradstein *et al.*, 2003). Schuster (1992) remarked that the species “apparently hardly occurs wild” and is often found in association with human habitation in Japan, for example around “privies” (traditional toilets).

Perhaps most is now known about *Monosolenium* ecology in culture in tropical aquaria (Gradstein *et al.*, 2003); it is widely offered for sale as an aquarium plant and it readily grows into dense submerged colonies with thinner and more delicate thalli than plants growing in terrestrial colonies. In this respect it is similar to other aquatic Marchantiales such as *Riccia fluitans* L. However, there do not appear to be any reports of it growing as a submerged aquatic plant in the wild.

The world distribution of *Monosolenium* was mapped by Bischler (1998) who showed that it has a very limited subtropical Asiatic distribution from NW and NE India, southern China and Taiwan to southern Japan. The new record from Nepal fits neatly within this distribution range.

Acknowledgments. The National Geographic Society is thanked for financial support for the botanical survey work in Royal Bardia National Park, and Professor Dr. K.K. Shrestha, Central Department of Botany of Tribhuvan University, Kathmandu, for creating the opportunity for NP to undertake the bryological part of this study. The Natural History Museum of Nepal is acknowledged for provision of research facilities. Dr D.K. Singh, Botanical Survey of India, Kolkata, is thanked for permission to cite unpublished literature, Dr. Robert Magill, Missouri Botanical Garden, for providing literature, and Professor Robbert Gradstein, University of Göttingen, for helpful comments on the manuscript.

REFERENCES

- BISCHLER H., 1998 — Systematics and evolution of the genera of Marchantiales. *Bryophytorum bibliotheca* 51: 1-201.
- BOISSELIER-DUBAYLE M.-C., LAMBOURDIÈRE J. & BISCHLER H., 2002 — Molecular phylogenies support multiple morphological reductions in the liverwort subclass Marchantiidae (Bryophyta). *Molecular phylogenetics and evolution* 24: 66-77.

- CAMPBELL D.H., 1923 — An interesting liverwort. *Science* 57: 384-385.
- CHEN P.C., 1955 — Bryophyta Nova Sinica. *Feddes repertorium* 58: 23-52.
- FORREST L.L., DAVIS E.C., LONG D.G., CRANDALL-STOTLER B.J., CLARK A. & HOLLINGSWORTH M.L., 2006 — Unraveling the evolutionary history of the liverworts (Marchantiophyta): multiple taxa, genomes and analyses. *The bryologist* 109: 303-334.
- GOEBEL K., 1910 — Archegoniatenstudien. XIII. *Monosolenium tenerum* Griffith. *Flora* 101: 43-97.
- GRADSTEIN S.R., REINER-DREHWALD E. & MUTH H., 2003 — Über die Identität der neuen Aquarienpflanze “*Pellia endiviifolia*”. *Aqua-planta* 3: 88-95.
- GRIFFITH W., 1849 — *Notulae ad Plantas Asiaticas*. Part II. Hepaticae. Calcutta, Bishop's College Press, pp. 285-352.
- HATTORI S., 1942 — Notulae de Hepaticis Japonicis (II). *Journal of Japanese botany* 18: 66-77.
- HATTORI S., 1944 — Contributio ad floram hepaticarum Austro-Kiusiuensem. *Bulletin of the Tokyo science museum* 11: 1-203.
- HATTORI S., 1951 — On the distribution of the Hepaticae of Shikoku and Kiushiu (southern Japan). *The bryologist* 54: 103-118.
- HATTORI S., 1952 — Hepaticae of Shikoku and Kyushu, southern Japan. *Journal of the Hattori botanical laboratory* 8: 21-46.
- HORIKAWA Y., 1934 — Monographia Hepaticarum Australi-Japonicarum. *Journal of science of the Hiroshima university series B, Division 2 (Botany)* 2(2): 101-325.
- INOUE H., 1966 — Monosoleniaceae, a new family segregated from the Marchantiaceae. *Bulletin of the national science museum Tokyo* 9: 115-120.
- INOUE H., 1976 — *Illustrations of Japanese Hepaticae*. Volume 2. Tokyo, Tsukiji Shokan.
- KAMIMURA M., 1952 — *Contributio ad floram Hepaticarum Shikokuensem*. Kochi.
- KAPILA S. & KUMAR S.S., 1995 — A study on long lost liverwort — *Monosolenium tenerum* Griff. In KUMAR S.S. (ed.), *Recent Studies on Indian Bryophytes*. Dehra Dun, Bishen Singh Mahendra Pal Singh, pp. 59-64.
- KASHYAP S.R., 1924 — A long-lost liverwort. *Journal of the Indian botanical society* 3: 181.
- MILLER H.A., WHITTIER H.O. & WHITTIER B.A., 1983 — Prodrum florae hepaticarum polynesiae with a key to genera. *Bryophytorum bibliotheca* 25: 1-423.
- SCHUSTER R.M., 1992 — *The Hepaticae and Anthocerotae of North America*. Volume 6. Chicago, Field Museum of Natural History.
- SHIN T., 1968 — Flora of Hepaticae in the Ryukyu Archipelago I. *Science reports of Kagoshima university* 17: 185-213.
- SINGH S.K. & SINGH D.K., 2007 — Some new and noteworthy records of some Hepaticae and Anthocerotae from Western Himalaya, India. *Cryptogamie, Bryologie* 28: 103-108.
- STEPHANI F., 1898-1900 — *Species Hepaticarum*. Vol. 1. Genève, Bale & Lyon, Herbarium Boissier.
- YANG B.-Y., 1965 — The discovery of *Monosolenium tenerum* in Taiwan. *Taiwania* 11: 29-34.