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# Abundant but neglected: Past and present of liverwort (Marchantiophyta) studies in Malaysia

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**Abstract –** The history of liverwort studies in Malaysia is briefly reviewed. Three historical periods are recognized: (1) 1838-1938, the first 100 years of liverwort collecting in Malaysia; (2) 1950-2000, during which most collections were made, many new taxa were found and described, and studies were carried out by well-known foreign bryologists e.g., by Zennoske Iwatsuki and Masami Mizutani from the Hattori Botanical Laboratory, Japan; (3) 2000-present day, in which liverwort work has been continued by foreign and local bryologists. Thus far, 747 species and 42 infraspecific taxa of liverworts have been recorded from Malaysia or almost 15% of world diversity of liverworts. However, only few taxonomic treatments and identification keys have been published dealing with Malaysian liverworts. An urgent effort should be undertaken to systematically and intensively collect and study this interesting group of plants in Malaysia.

**Liverwort / Malaysia / Marchantiophyta**

## INTRODUCTION

Liverworts (Marchantiophyta) comprised ca. 6500 currently accepted species worldwide (Söderstrom *et al.,* 2016). Thus far, 789 species and infraspecific taxa have been reported for Malaysia (Pócs & Lee, 2016), representing about 15% of the world's known liverwort species. The vascular flora of Malaysia has been well-studied taxonomically, e.g. in the framework of the project "Flora of Peninsular Malaysia" (Kiew *et al.,* 2010, 2011, 2012, 2013, 2015; Parris *et al.,* 2010, 2013), and "Tree Flora of Sabah and Sarawak" (Soepadmo & Wong, 1995; Soepadmo *et al.,* 1996, 2002, 2004, 2007, 2011, 2014; Soepadmo & Saw, 2000). Non-vascular

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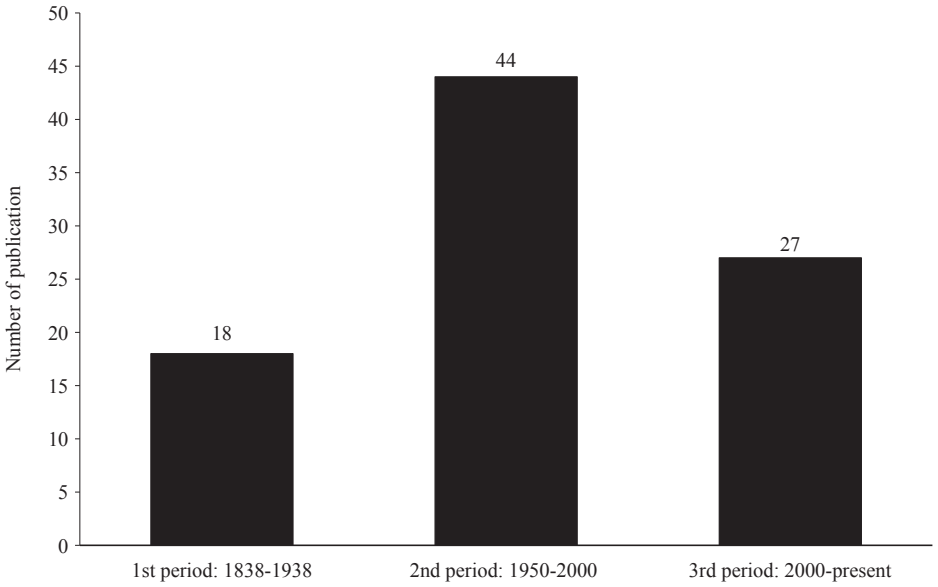


Fig 1. Number of publications published for each period.

plants including liverworts, however, have received much less attention and only a few studies have been conducted dealing with these plants. The aim of the present paper is to review the chronological sequence and history of liverwort exploration in Malaysia. The number of publications recorded for each period are given in Figure 1.

## HISTORY OF LIVERWORT EXPLORATION IN MALAYSIA

### First period: 1838-1938 – The first 100 years of liverwort collecting in Malaysia

The first collection of liverworts in Malaysia was made on Penang Island at the beginning of the 19th century probably by Nathaniel Wallich (the famous Danish botanist who carried out major explorations in India and Southeast Asia). Twelve liverwort species were recorded based on this early collections from Penang, including *Jungermannia ligulata* Lehm. & Lindenb. (= *Mastigolejeunea ligulata* (Lehm. & Lindenb.) Schiffn.) described in 1834 by the German botanists J.G.C. Lehmann & J.B. Lindenberg, and *Ptychanthus tumidus* Nees (= *Schiffneriolejeunea tumida* (Nees) Gradst.), described in 1838 by C.G. Nees von Esenbeck (Nees, 1838). Subsequently, four species were gathered in Perak, Johor (most probably), Sabah and Sarawak (Lehmann, 1844; Taylor, 1846; Mitten, 1861; Stephani, 1890; Schiffner, 1893, 1898). During 1865-1867, Odoardo Beccari, an Italian naturalist, collected liverworts in Sarawak. His specimens were studied by De Notaris (1874, 1876) who recorded a total of 51 species including 28 new species and one new genus, i.e., *Diploscyphus* de Not. (= *Conoscyphus* Mitt.). Furthermore, Franz Stephani, a

German bryologist, in his six volumes of *Species Hepaticarum* (1898-1924) reported 61 species of liverworts from Malaysia viz. 22 from Melaka, 32 from Sarawak and 7 from Penang Island. Most of the specimens were collected by Henry Nicholas Ridley, Odoardo Beccari and Alfred Hart Everett. Stephani's work was critically revised by later authors, first of all by Verdoorn (e.g., 1930, 1934) who described one new *Frullania* species from Mt. Kinabalu, *Frullania clemensiana*, based on the collections of Joseph Clemens and Mary Knapp Clemens (Verdoorn, 1932). Eifrig (1937) in his Indo-Malayan *Taxilejeunea* monograph listed four species of liverworts from Malaysia. Since then, no liverworts specimens were collected in Malaysia until after the Second World War.

**Second period: 1950-2000 – the blooming period of liverwort studies in Malaysia**

Major contributions to Malaysian liverworts were made during this period by Japanese bryologists. The second period started with the publications of Herzog (1950, 1952), who reported 141 liverwort taxa, including 35 new species and two new, peculiar, rheophytic genera (*Stenorrhipis* Herzog, *Aphanotropis* Herzog), from Gunung Dulit, Sarawak. The specimens studied were collected by the famous English forest ecologist and bryologist Paul W. Richards in the framework of Oxford University Expedition to Sarawak in 1932. The Dutch bryologist Willem Meijer did extensive liverwort collecting in Sabah in the 1950s, and published a few short papers based on this material (Meijer, 1957, 1958). Further citations of Meijer's collections are found scattered in various taxonomic revisions and monographs dealing with Asiatic liverworts. The first bryological expedition to Mt. Kinabalu was carried out by two Japanese bryologists, Zennoske Iwatsuki and Masami Mizutani, in 1963. About 6000 specimens of liverworts were collected (see Hattori & Kamimura, 1971) and many contributions based on these collections have been published such as Hattori (1963, 1964, 1966, 1974) who described three new species and one new subspecies, Kitagawa (1964, 1967, 1969a, 1970) who reported five new species including one new genus (*Iwatsukia* Kitag.), Mizutani (1966, 1969, 1970, 1973, 1974) published 28 new species, Kuwahara (1965) who recorded one new species and one new variety, and Hattori and Kamimura (1971) who proposed a new genus (*Steerea* S.Hatt. & Kamim.). Also based on these large amount of materials, 121 species in 16 genera of Lejeuneaceae were recorded and 38 species were described as new to science, including several in honour of Dr. Iwatsuki and Dr. Mizutani, viz., *Andrewsianthus mizutanii* N. Kitag, *Frullania mizutanii* Kamim. & S. Hatt., *Jungermannia iwatsukii* Amakawa, *Radula iwatsukii* K. Yamada, *Radula mizutanii* K. Yamada, *Saccogynidium iwatsukii* S. Hatt. and the genus *Iwatsukia*. Probably the most unusual new liverwort taxon was *Mizutania riccardioides* Furuki & Z. Iwats., first collected by Dr. Mizutani on Mt. Kinabalu and later found in several other localities in Borneo and in the Cameron Highlands, Peninsular Malaysia (Furuki & Iwatsuki, 1989). This minute thalloid liverwort was initially placed in a family of its own in the thalloid subclass Metzgeriidae, but was recently, very unexpectedly, shown to be a member of the leafy liverwort family Calypogeiaceae based on molecular evidence (Masuzaki *et al.*, 2010). Subsequently, several other Japanese bryologists visited Mt. Kinabalu as well as Peninsular Malaysia (Penang Island, Cameron Highlands) and reported further new species (Inoue, 1967a, 1967b, 1975; Kitagawa, 1969b, 1971; Kitagawa & Kodama, 1973, 1974a, 1974b, 1975a, 1975b; Kodama & Kitagawa, 1974; Kodama & Narita, 1974; Kodama, 1976). Meanwhile, Johnson (1958, 1972) published an account of the thallose liverworts found in Peninsular Malaysia and a short report on bryophytes including liverworts

from Gunung Benom, Pahang. Other contributions to the hepaticological knowledge of Malaysia were reported by Tixier (1971, 1974, 1980) in Fraser Hill, Kedah Peak (Gunung Jerai), and Cameron Highlands, and also by Wolseley *et al.* (1996) in their quantitative and qualitative sampling of epiphytic cryptogams in logged and unlogged plots study at Pasoh Forest Reserve. Catalogues have been published for Sabah and Sarawak by Menzel (1988) and for Mt. Kinabalu by Frahm *et al.* (1990) in the framework of the German BRYOTROP expedition to Mt. Kinabalu in 1986. The expedition resulted in a detailed description of the bryophyte communities along the elevational gradient on Mt. Kinabalu, with details on the habitats of liverwort species. Finally, Schäfer-Verwimp (2001, 2006) and Dürhammer and Schäfer-Verwimp (1995) collected liverworts in Peninsular Malaysia and reported new localities for the rare *Lejeunea pilifera* Tixier (= *L. patriciae* Schäf.-Verw.), a species first described from Malaysia.

**Third period: 2000-present – the rise of work by Malaysian hepaticologists**

The first checklist of the liverworts for the whole of Malaysia was published by Chuah-Petiot (2011), who reported a total of 758 species and infraspecific taxa in 122 genera and 38 families. Subsequently, an updated catalogue of Lejeuneaceae (the largest family in the liverworts) of Malaysia was presented by Lee *et al.* (2013), enumerating a total of 274 species and 10 infraspecific taxa, in 30 genera. The largest number of species was found in the state of Sabah with 197 species, followed by Pahang with 103 species. *Cololejeunea* is the largest genus of Lejeuneaceae in Malaysia with 76 species, followed by *Lejeunea* (35 spp.), *Drepanolejeunea* (27 spp.), *Cheilolejeunea* (22 spp.) and *Colura* (19 spp.). A comprehensive taxonomic revision of the genus *Lejeunea* in Malaysia was presented by Lee (2013) based on ca. 1000 specimens, leading to the recognition of 30 species and two varieties for the area. Several additional new discoveries and observations were made based on this study (Lee *et al.,* 2011a, 2011b, 2011c, 2014; Lee & Gradstein, 2013). Other recent studies on Malaysian liverworts by local or by foreign bryologists in cooperation with Malaysian bryologists, include, e.g., a study on the taxonomy of large genus *Bazzania* (52 species in Malaysia) with reports of 11 species new to the country and a key to 26 species known from Peninsular Malaysia (Cheah & Yong, 2016), descriptions of new Malaysian species of the genera *Eotrichocolea, Mastigolejeunea* and *Riccardia* (Katagiri *et al.,* 2012; Furuki *et al.,* 2013; Sukkharak, 2014), integrative taxonomic studies (including molecular analysis) on the peculiar genera *Metzgeriopsis* (Gradstein *et al.,* 2006), *Mizutania* (Masuzaki *et al.,* 2010) and the species *Lejeunea pulchriflora* (Lee *et al.,* 2016), and results of new floristic explorations (Pócs *et al.,* 2014; Pócs & Lee, 2016). Studies on the ultrastructure of *Mizutania* were carried out by Pressel *et al.* (2011). Finally, several chemical studies on Malaysian liverworts were recently conducted (e.g., Nagashima *et al.,* 1991; Buchanan *et al.,* 1996; Leong & Harrison, 1997; Tori *et al.,* 2000; Sukkharak *et al.,* 2011; Fu *et al.,* 2013; Bakar *et al.,* 2015; Ng *et al.,* 2016a, 2016b).

## CONCLUSION

Liverworts are very abundant and occur everywhere in tropical rainforests in Malaysia, however, they have been frequently overlooked or ignored by botanists. Many forests and mountains in Malaysia are largely unexplored from a hepaticological perspective. Liverworts have been overlooked by botanists due to their tiny size,

many of them being only a few millimetres tall. Furthermore, the study of liverworts and the identification of the species is a challenging task due to their morphological intricacy and plasticity. Lack of well-illustrated, up-to-date, comprehensive field guides for identifying Malaysian species is also another hurdle in the study of liverworts. Thus, there is an urgent need for more area-based studies on the species diversity and taxonomy of the liverworts of Malaysia. It is expected many new discoveries will be made in the future as Malaysia is endowed with one of the richest biodiversities in the world. Of special interest for study are the endemic genera *Aphanotropis* Herzog (Sarawak) and *Cephalolejeunea* Mizut. (Mt. Kinabalu), which are currently known from only one collection (the type) and whose taxonomic affinities are still unclear. Chemical study of Malaysian liverworts is also a very promising field as liverworts store many unique secondary metabolites in their oil bodies. The chemical compounds show highly promising biological effects such as antibacterial, antimicrobial and antifungal activities, and may be used as antioxidants and anticancer agents (Asakawa *et al.,* 2013).

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