Liverwort genera of Thailand

Phiangphak Sukkharak
Department of Biology, Faculty of Science, Burapha University

Phiangphak Sukkharak is an Associate Professor of Botany at the Department of Biology at Burapha University, Chonburi, Thailand. She completed her primary and secondary schools in Nan, where she was born in 1982. Later, she received the scholarship from the Development and Promotion of Science and Technology Talents Project (DPST) to continue her high school at Yupparaj Wittayalai School in Chiang Mai. She has been working on the Taxonomy of bryophytes, especially liverworts for more than 17 years. Her interest started during her second year of Bachelor's degree at Chiang Mai University. She submitted a proposal to the Biodiversity Research and Training program of Thailand and got the financial support to study the bryophytes of Kun Wang community forest in Chiang Mai. After that, she studied the liverworts of Khao Nan in Nakhon Si Thammarat for her master's thesis at Chulalongkorn University in Bangkok. In 2007, she met the world expert of the liverworts, Prof. Stephan Robbert Gradstein, at the World Conference of Bryology in Kuala Lumpur, Malaysia and was invited to Göttingen, Germany to conduct a monograph of the liverwort genus *Thysananthus* by using morphological, chemical, and genetic analyses for her doctoral dissertation under his guidance. However, intermediate taxa between *Thysananthus* and *Mastigolejeunea* were found. Consequently, after graduation, she continues working on *Mastigolejeunea* leading to the treatment of *Mastigolejeunea* as a subgenus of *Thysananthus* based on morphological and molecular evidences. Recently, she has been working on the revision of the liverwort genera in Thailand. The genera *Frullania, Pleurozia,* and *Metzgeria* in Thailand are revised and the Thai *Porella, Acrobulbus,* and *Syzygiella* are updated. She is also working on *Thysananthus* and *Frullania* for the Flora of Singapore project. She serves as a member of the Nomenclature Committee for Bryophytes of the International Association of Plant Taxonomists (2017-2023) and the Editorial Board of Journal of the Hattori Botanical Laboratory (2017-present). Moreover, after receiving the Young Scientist Award from the Foundation for the Promotion of Science and Technology under the Patronage of His Majesty the King in 2015 until now, she has been invited to give stimulating talks and to conduct the outreach activities for students in universities and high schools throughout Thailand to share her research experience, encourage, and motivate them into scientific careers, as well as increase their awareness of this understudied group of plants. She also was selected by the Association of the Thai Government Scholarship Student, Thailand for the Young Rising Star of Thai Government Scholarship Student Award in 2020 for her achievement and her service to the scientific and educational community.

LIVERWORT GENERA OF THAILAND

Phiangphak Sukkharak
Department of Biology, Faculty of Science
Burapha University

Liverwort genera of Thailand

Editor: Korakot Nganvongpanit

ISBN (e-book): 978-616-398-690-0

Author: Phiangphak Sukkharak

Plublished: Chiang Mai University Press
Office of Research Administration
Tel: 0 5394 3603-4
Fax: 0 5394 3600
https://cmupress.cmu.ac.th, E-mail: cmupress.th@gmail.com

Print: April 2022

Price: 295 Baht

Cover photographs
Front cover, from top to bottom: *Metzgeria furcata* (L.) Corda as a representative of thalloid liverwort showing gametophyte and sporophyte and *Anastrophyllum piligerum* (Nees) Steph. as a representative of leafy liverwort showing gametophyte and sporophyte (from Sukkharak, 2007).

Back cover, from left to right: *Bazzania tridens* (Reinw., Blume & Nees) Trevis. var. *tridens* as a representative of leafy liverwort showing incubous insertion and flagelliform branch and *Marchantia papillata* Raddi subsp. *grossibarba* (Steph.) Bischl. as a representative of thalloid liverwort showing gemma cup with gemmae on thallus (from Sukkharak, 2007, with update).

All figures are made by author.

This book has passed the evaluation by bryologists and botanists from different institutes and approval for the academic work publishing of book/ textbook by Chiang Mai University Press.

Contact: Chiang Mai University Press
Tel: 0 5394 3605 Fax: 0 5394 3600
https://cmupress.cmu.ac.th, E-mail: cmupress.th@gmail.com

Forword

Liverworts, (division Marchantiophyta), are any of more than 7,000 species of small non-vascular spore-producing plants. Liverworts are distributed worldwide, though they are most commonly found in the tropics area. In Thailand, liverworts have been collected and studied since 1899.

The book "Liverwort genera of Thailand" by Assoc. Prof. Dr. Phiangphak Sukkharak, Department of Biology, Faculty of Science, Burapha University, provides a synopsis on the liverwort genera of Thailand, in which 520 species in 93 genera and 39 families have been reported, representing about 7% of the world's liverwort species. The book consists of an introduction to liverworts, history of liverwort studies in Thailand, classification of liverworts in Thailand, key to genera of liverworts found in Thailand, generic descriptions, illustrations, discussion of the most important features for identification, data on the distribution and ecology, as well as the number of species worldwide and in Thailand.

As a representative of the publisher, I truly believe that this book will be useful to the worldwide academic community. It is suitable for both university students and scientists in the field, and is written based on the author's extensive research experience. The author herself has received numerous academic awards, as mentioned in her CV, guaranteeing her outstanding performance.

Professor Dr. Korakot Nganvongpanit
Editor

Preface

Liverworts of Thailand have been collected and studied since 1899. However, no identification tool has yet been published. This book provides the synopsis of liverwort genera of Thailand, in which 520 species in 93 genera and 39 families, have been reported, representing about 7% of the world's liverwort species. Of these, one genus, *Cryptolophocolea*, is newly reported for Thailand. In addition, as *Thysananthus ciliaris* (Sande Lac.) Sukkharak in Sukkharak & Gradst. is currently known only from a single population in the country, it is suggested here to be placed in the red list of Thai bryophytes. The book consists of an introduction to liverworts, history of liverwort studies in Thailand, classification of liverworts of Thailand, key to genera of liverworts found in Thailand, generic descriptions, illustrations, discussion of the important features for identification, data on the distribution and ecology as well as the numbers of species in the world and Thailand.

Phiangphak Sukkharak
Chonburi, March 2022

Acknowledgements

I am deeply grateful to Chris Cargill for useful suggestions and English improvement. I express my gratitude to the curator and the staffs of the Department of National Parks, Wildlife and Plant Conservation, Thailand (BKF) for making the specimens available and their hospitality upon my visits. I would like to thank Sahut Chantanaorrapint and Chatchaba Promma for providing information. I am most grateful to the reviewers for suggestions, comments, and corrections on the manuscript that have lead to improvement of this book.

Contents

		Page
Forword		iii
Preface		iv
Acknowledgements		v
Contents		vi
Abbreviations		vii
Herbarium Acronym		viii
Chapter 1	**Introduction of liverworts**	1
	Leafy liverworts	3
	Thalloid liverworts	14
Chapter 2	**Historical development of liverwort studies in Thailand**	19
	First period: 1899-1977 – Studies by foreign bryologists and botanists	19
	Second period: 1977-present – Studies primarily by Thai bryologists	21
	Future prospects	24
Chapter 3	**Classification of liverworts of Thailand**	27
Chapter 4	**Key to liverwort genera of Thailand**	49
Chapter 5	**Liverwort genera of Thailand**	59
Analysis		218
Summary		219
Glossary		220
References		227
Index to Taxa		249

Abbreviations

ca. — *circa*, approximately

cf. — *confer*, compare

et al. — *et alii*, and others

fo. — *forma*, form

l.c. — *loco citato*, as cited above

nom. cons. — *nomen conservandum*, conserved name

per. com. — personal communication

s.n. — *sine numero*, without number

subgen. — subgenus

subsp. — subspecies

syn. — synonym

var. — variety

Herbarium Acronym

Herbarium codes follow Thiers (continuously updated).

BCU — Chulalongkorn University, Bangkok, Thailand

BKF — Department of National Parks, Wildlife and Plant Conservation, Bangkok, Thailand

Hb. Burapha Univ. — Herbarium of Department of Biology, Faculty of Science, Burapha University, Chonburi, Thailand

Chapter 1
INTRODUCTION TO LIVERWORTS

Liverworts or hepatics are grouped with mosses and hornworts as bryophytes, which are non-vascular, seedless, flowerless, and spore-producing land plants (Figure 1). Bryophytes have the haploid gametophyte generation as the dominant phase of the life cycle, with the sporophyte dependent on the gametophyte, whereas all vascular plants have the diploid sporophyte generation as their dominant phase. In liverworts, the gametophyte generation begins with spores which germinate into a multicellular protonema with unicellular rhizoids. Later the protonema finally differentiates into either a leafy or thalloid form. Each form produces eggs and sperm via the archegonium and antheridium, respectively. When mature, the sperm swims towards the archegonium and fertilizes the egg. This leads to a zygote which is the starting point of the sporophyte generation. As the zygote develops further, the embryo differentiates into a foot which penetrates the gametophyte together with elongation of the seta after the sporangium or capsule has differentiated and matured completely. The capsule opens by four longitudinal valves and with the help of elaters, the spores are shed (Figure 2).

Plant Kingdom

Non-vascular plants (Bryophytes)

- Phylum Marchantiophyta (Hepaticae, Liverworts)
- Phylum Bryophyta (Musci, Mosses)
- Phylum Anthocerotophyta (Hornworts)

Vascular plants (Tracheophytes)

Seedless plants

- Phylum Lycophyta
- Phylum Monilophyta

Seed plants

- Naked seed plants (Gymnosperms)
  - Phylum Coniferophyta
  - Phylum Cycadophyta
  - Phylum Ginkgophyta
  - Phylum Gnetophyta
- Flowering plants (Angiosperms)
  - Phylum Anthophyta

Figure 1. The members of plant kingdom showing the position of liverworts (Reece et al., 2014; Frey & Stech, 2009).

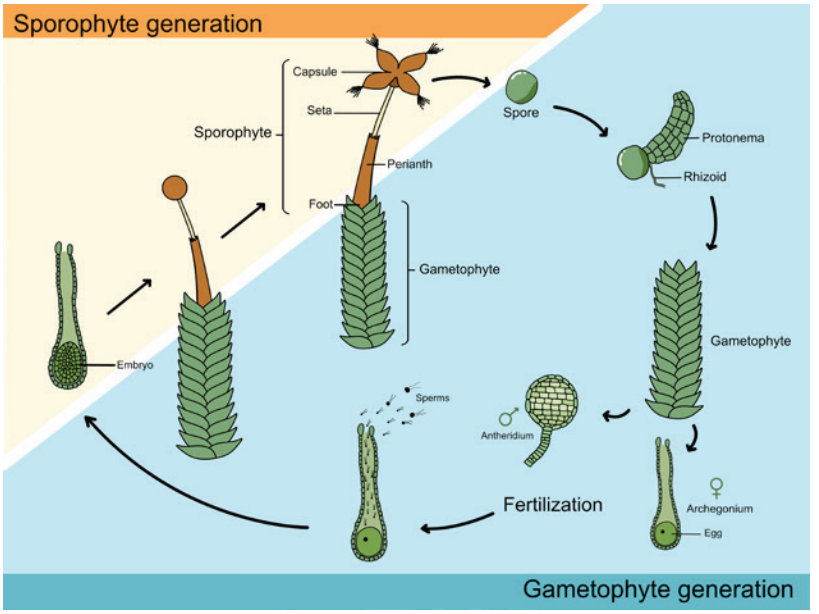

Figure 2. Life cycle of a liverwort. See text for details.

The term "liverwort" is from the Middle English *wort* meaning "plant" and "liver" referring to the first-named liverworts similar to a liver in shape. The term "hepatic" comes from the Greek *hēpatikos* meaning "liver" referring

to the plant's resemblance to the organ as well. Liverworts consist of about 7,280 species in 386 genera in 87 families, with the four largest genera being *Plagiochila* (Dumort.) Dumort. (ca. 697 species), *Frullania* Raddi (ca. 576 species), *Cololejeunea* (Spruce) Steph. (ca. 405 species), and *Lejeunea* Lib. (ca. 384 species) (Söderstrom et al., 2016). The morphology of liverworts in this chapter follows Gradstein et al. (2001), Goffinet and Shaw (2009), and Vanderpoorten and Goffinet (2009). Based on their gametophyte, there are two main types of liverworts: leafy and thalloid liverworts.

LEAFY LIVERWORTS

The gametophytes are leafy, composed of a stem (caulidium or caulid, *plural* caulidia or caulids) and leaves (phyllidum or phyllid, *plural* phyllidia or phyllids). In creeping leafy liverworts, the side that contacts with the substrate is called the ventral side and the other side refers to dorsal side. In erect leafy liverworts, the term postical is used for the side bearing underleaves and the opposite side is the antical.

Rhizoids

Rhizoids are unicellular with a smooth inner wall and are scattered or in fascicles on the ventral or postical side of the stems (Figures 28A-B, F; 29E; 59K; 64J). They develop from stem epidermal cells or special cells of the underleaf base. In epiphyllous liverworts, rhizoids are grouped together to form a secondary rhizoid disc (Figures 61A, C). In *Radula* Dumort., the rhizoids are restricted to the ventral lobules. However, rhizoids are absent in some taxa. The function of rhizoids is to attach the plant to the substratum.

Stems

In leafy liverworts, the stem develops from three merophytes consisting of two lateral merophytes and ventral one. The width of the ventral merophyte is the number of the epidermal cell rows across the ventral side of the stems. It is related to the robustness of the stem and can be used for distinguishing some members of Lejeuneaceae. The stem cells in cross section are similar or differentiaed into inner medullary cells, in which a central strand can occur, and outer cortical cells, in which the outermost layer is called the epidermis (Figure 37G). According to Crandall-Stotler (1972) and Gradstein et al. (2001), there are two main types of branches: terminal (athecal or collarless) branches and intercalary (gyrothecal or sheathed) branches.

The terminal (athecal or collarless) branch is formed directly from branch initials. It diverges from the main stem at 45-60° and has no basal collar.

1. *Frullania*-type branch develops from the ventral segment-half of the lateral merophyte so it replaces the ventral half of the leaf and is associated with the half-leaf on its dorsal side. The cells of the branch fuse with those of the main stem (Figure 3A).

2. *Microlepidozia*-type branch develops from the dorsal segment-half of the lateral merophyte so it replaces the dorsal half of the leaf and is associated with the half-leaf on its ventral side. The cells of the branch fuse with those of the main stem (Figure 3B).

3. *Acromastigum*-type branch develops from the anodic segment-half of ventral merophyte so the branch develops on the ventral side of the stem and is associated with a modified half-underleaf (Figure 3C).

4. *Radula*-type branch develops from the lateral merophyte so it is associated with the unmodified leaf. The cells of the branch fuse with those of the main stem (Figure 3D).

5. *Fontinalis*-type branch develops from the second cortical cell below the leaf so it is associated with the unmodified leaf which never inserts on the branch and at a distance above the branch (Figure 3E).

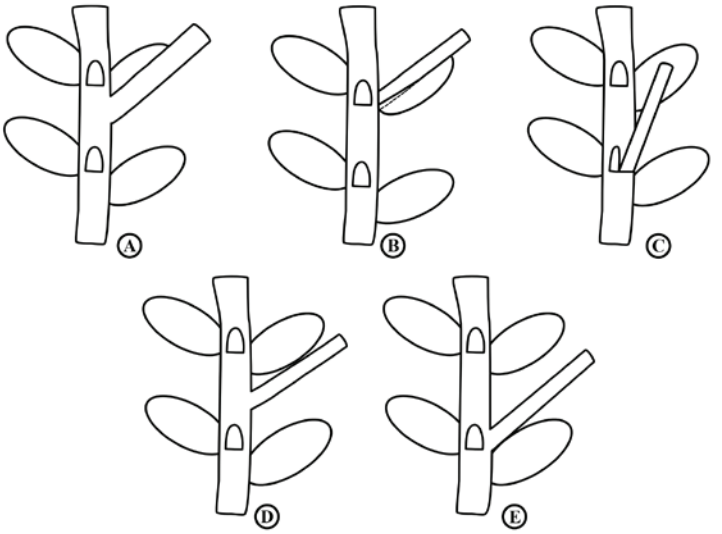

Figure 3. The terminal (athecal or collarless) branches. A. *Frullania*-type branch, ventral view. **B.** *Microlepidozia*-type branch, ventral view. **C.** *Acromastigum*-type branch, ventral view. **D.** *Radula*-type branch, ventral view. **E.** *Fontinalis*-type branch, ventral view.

The intercalary (gyrothecal or sheathed) branch is formed from superficial cells of leaf primordia. It diverges from the main stem at 90° and has a basal collar. If the branch is in the lateral leaf axil, it is called the lateral-intercalary branch but if the branch is in the underleaf axil, it is referred to as the ventral-intercalary branch.

1. *Bazzania*-type branch develops from a medullary cell in ventral merophyte with cortical cells so it occurs from the ventral side of the stem or around an unmodified underleaf with unlobed basal collar (Figure 4A).

2. *Plagiochila*-type branch develops from a medullary cell in the ventral part of a lateral merophyte with cortical cells so it occurs at the ventral side of an unmodified leaf with unlobed multilayered basal collar (Figure 4B).

3. *Bryopteris*-type branch develops from inner cells of a young basiscopic cortical cell with the outer cells so it occurs directly below an unmodified leaf with an unlobed 1 cell-layered basal collar fused with postical margins of the associated leaf (Figure 4C).

4. *Anomoclada*-type branch develops from the dorsal part of a lateral merophyte with cortical cells so it occurs on the dorsal side of the stem at an unmodified leaf with multilayered basal collar (Figure 4D).

5. *Lejeunea*-type branch develops from a basiscopic cortical cell with brace cells so it occurs directly below an unmodified leaf with lobed 1 cell-layered basal collar (Figure 4E).

6. Adventive *Radula*-type branch develops from the second cortical cell below a leaf in the differentiated region of the stem with segmentations of the branch apical cell so it occurs a short distance below an unmodified leaf with lamellae consisting basal collar (Figure 4F).

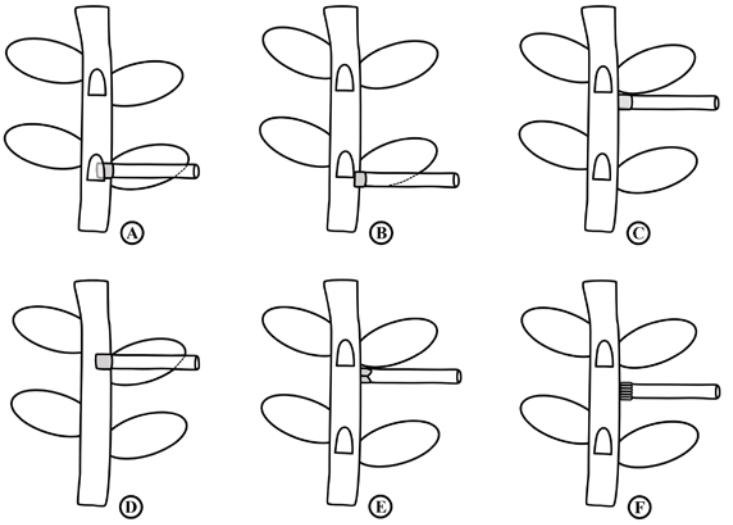

Figure 4. The intercalary (gyrothecal or sheathed) branches. A. *Bazzania*-type branch, ventral view. **B.** *Plagiochila*-type branch, ventral view. **C.** *Bryopteris*-type branch, ventral view. **D.** *Anomoclada*-type branch, dorsal view. **E.** *Lejeunea*-type branch, ventral view. **F.** Adventive *Radula*-type branch, ventral view.

Apart from an ordinary branch, there exists a flagelliform branch with its scale-like leaves (Figures 5; 30K) and a stolon, which refers to a branch without leaves. In addition, in some members of Lejeuneaceae, the innovation, in which the branch is formed below the perianth, is presented. Following Gradstein et al. (2001), two types of innovations are recognized: lejeuneoid and pycnolejeuneoid.

1. The lejeuneoid innovation refers to the type in which the basal-most position is a lateral leaf (Figure 6A).

2. The pycnolejeuneoid innovation refers to the type in which the basal-most position is an underleaf (Figure 6B).

Figure 5. Flagelliform branches in *Bazzania tridens* (Reinw., Blume & Nees) Trevis. var. *tridens*. f = flagelliform branch.

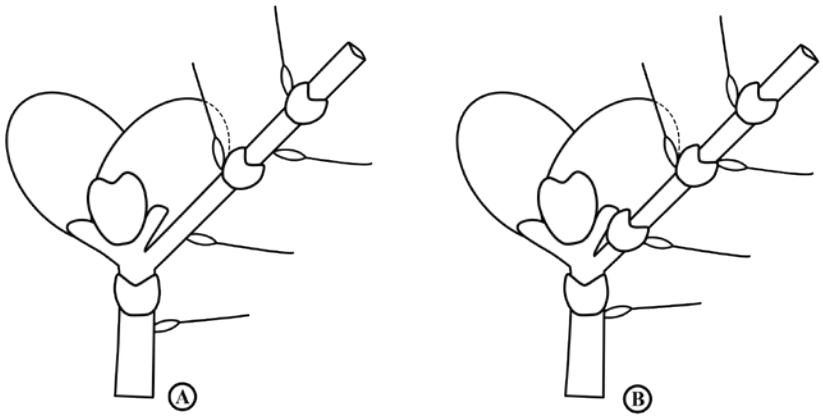

Figure 6. Innovation. A. Lejeuneoid innovation, ventral view. **B.** Pycnolejeuneoid innovation, ventral view.

Leaves

The leaves of leafy liverworts originate from two to three leaf-initial cells. Therefore, they are arranged in two to three rows: two lateral rows called lateral leaves and one ventral row called underleaves (amphigastria, *singular* amphigastrium), which maybe absent in some taxa. Underleaf bases may be free or adnate with leaves either on one side or both sides. In some genera, a stylus is recognized (Figure 59C). The insertion of underleaves is transverse but three types of insertion are recognized for lateral leaves including incubous, succubous, and transverse.