

LIVERWORT FLORA OF THE JIRISAN NATIONAL PARK IN KOREA
ФЛОРА ПЕЧЁНОЧНИКОВ НАЦИОНАЛЬНОГО ПАРКА ЧИРИСАН В КОРЕЕ

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Abstract

The liverwort flora of the Jirisan National Park was studied and analyzed to create a list of taxa, that includes 177 species. Of these, 14 species are recorded only in literature and 78 species are newly recorded for the Jirisan Mountains. One species (*Lopholejeunea subfusca*) was excluded from the list because its occurrence in the Jirisan mountains is doubtful. The flora is characterized by the dominance of the East Asian temperate elements with great participation of northern boreal and subalpine taxa. The rather noticeable diversity of the flora is explained by a wide altitudinal range in the study area, which results in a high diversity of communities and habitat types.

Резюме

Изучена и проанализирована флора печеночников национального парка Чирисан. По имеющимся данным, она включает 177 видов. Из них 14 видов известны только по литературным данным, а 78 видов приводятся для гор Чирисан впервые. Один вид (*Lopholejeunea subfusca*) исключен из списка, поскольку его присутствие в горах Чирисан вызывает сомнения. Для флоры характерно преобладание восточноазиатских неморальных видов с большим участием бореальных и субальпийских таксонов. Значительное разнообразие флоры объясняется большим высотным диапазоном исследуемой территории, что обуславливает большое разнообразие сообществ и типов местообитаний.

KEYWORDS: liverworts, flora, checklist, Jirisan mountains, South Korea, East Asia

INTRODUCTION

The Jirisan National Park designated South Korea's first national park in 1967, is located on the boundaries of Jeollabuk-do, Jeollanam-do and Gyeongsangnam-do provinces. It comprises differing plant communities, from warm-temperate broad-leaved deciduous forests and dispersed evergreen shrubs in the lowlands to extensive gravelly barrens with scattered vegetation, subalpine shrubs and crooked forests at upper elevations. The vascular plants of the Jirisan Mountains have been well studied with 2042 species recorded in the literature (Nakai, 1915; Jang *et al.*, 2007; Hyun, 2019). In contrast, only fragmentary information on the region's liverwort flora is available in a scattering of publications (Uno & Takahasi, 1940; Hong & Yoo, 1961; Hattori *et al.*, 1962; Song

& Yamada, 2009; Bakalin *et al.*, 2009). There is a similar paucity of data for the park's mosses with only 133 species recorded in the literature (Uno & Takahasi, 1940; Hong & Ando, 1961; Choe, 1962, 1980). However, considering the high-altitude landscape and plant community variations of the study area, we proposed that the diversity of liverworts in the park is likely greater than previously recorded. Moreover, comprehensive data on liverwort taxonomic diversity is urgently needed to inform conservation effort within the Korean Peninsula, and to improve understanding of liverwort distribution patterns and ecology in a broad, East Asian context. Thus, the aim of the present study is to provide new and comprehensive records of liverwort diversity in the Jirisan National Park.

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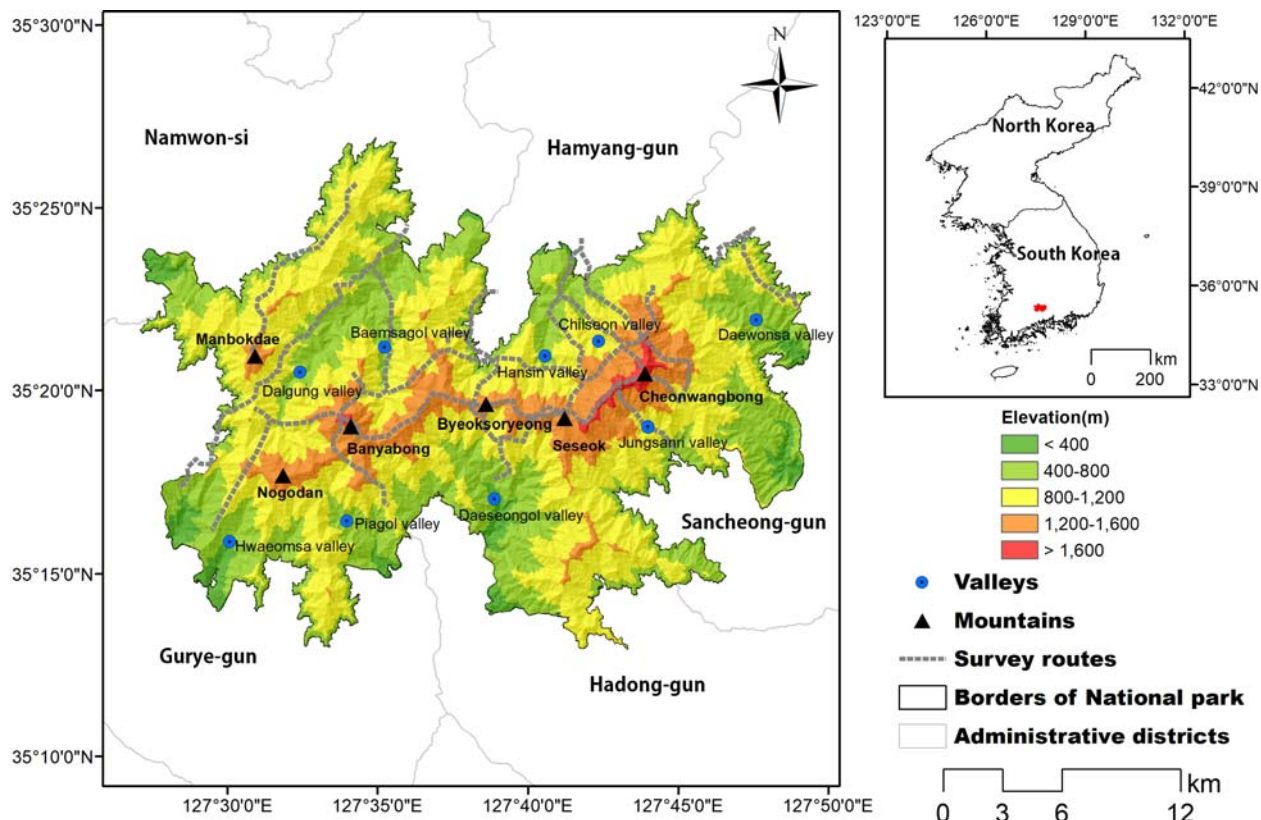


Fig. 1. The position of the Jirisan National Park within Korea and the surveyed routes in this study. For details of collections see supplementary materials.

STUDY AREA

The Jirisan National Park lies between longitudes 127°17'09"E – 127°49'29"E and latitudes 35°12'42"N – 35°26'43"N. Altitudes range from ca. 600 m a.s.l. in the lowlands to 1915 m a.s.l. at Cheonwangbong Mt., the highest point of mainland South Korea (Figs. 1–2). Other relatively high mountains in the park are Nogodan Mt. (1507 m a.s.l., western sector) and Banyabong Mt. (1732 m a.s.l., central sector). The total area of the national park is 472 km². The lowland area of the park is populated by broad-leaved deciduous forest that gradually changes into coniferous mountain forest near ridgelines intermixed with thickets of *Magnolia sieboldii* K. Koch and *Weigela florida* (Bunge) A. DC. sometimes forming a kind of crooked forest at high elevations (Park, 2019). The dominant species of the deciduous forest are *Quercus mongolica* Fisch. ex Ledeb., *Carpinus laxiflora* (Siebold & Zucc.) Blume, *Fraxinus rhynchophylla* Hance, and *Acer pictum* Thunb. var. *mono* (Maxim.) Franch. The dominant species of the coniferous mountain forest are *Abies koreana* E.H. Wilson, *Taxus cuspidata* Siebold & Zucc., *Pinus koraiensis* Siebold & Zucc., and *Abies nephrolepis* (Trautv. ex Maxim.). The ridgeline area is also rich in rocky outcrops and occasional gravelly barrens on steep slopes.

The mean annual temperature in the lowland area is 12.8°C, with the coldest month being January (average temperature varying from 8.4–1.4°C) and the warmest

month is August with an average temperature between 23.3 and 31.4°C. These parameters vary greatly depending on elevation and exposition. Mean annual precipitation in the lowlands is 2136 mm, with the summer maximum 1444.4 mm (<https://data.kma.go.kr>). At higher altitudes the amount of precipitation noticeably increases due to interception of wet air masses from the Pacific Ocean. The area of the park features southern inland climate. The dominant mineral rocks in the park are granitic gneiss (Shin, 2019).

Exploration of the hepatic flora of the park

The liverwort flora of the park has been studied for over 70 years, although there have been some lengthy breaks between reports in the literature. The first report on liverworts from the Jirisan Mountains was published by Uno and Takahashi (1940) who recorded four species (*Brachiolejeunea sandvicensis* (Gottsche) A. Evans (= *Acrolejeunea sandvicensis*), *Frullania fauriana*, *Frullania moniliata* (Reinw., Blume & Nees) Mont. subsp. *obscura* Verd. (= *Frullania appendiculata*) and *Madotheca setigera* (Steph.) S. Hatt. (= *Porella caespitans* var. *cordifolia*)) in the current territory of the park. Then Hong & Yoo (1961) recorded four species (*Frullania diversitexta*, *F. schensiana*, *F. taradakensis*, and *F. usamiensis*) as new for Korean flora. Hattori *et al.* (1962) recorded 50 taxa, also including 15 species new for the liverwort flora of the Korean Peninsula. After a long gap, Song &

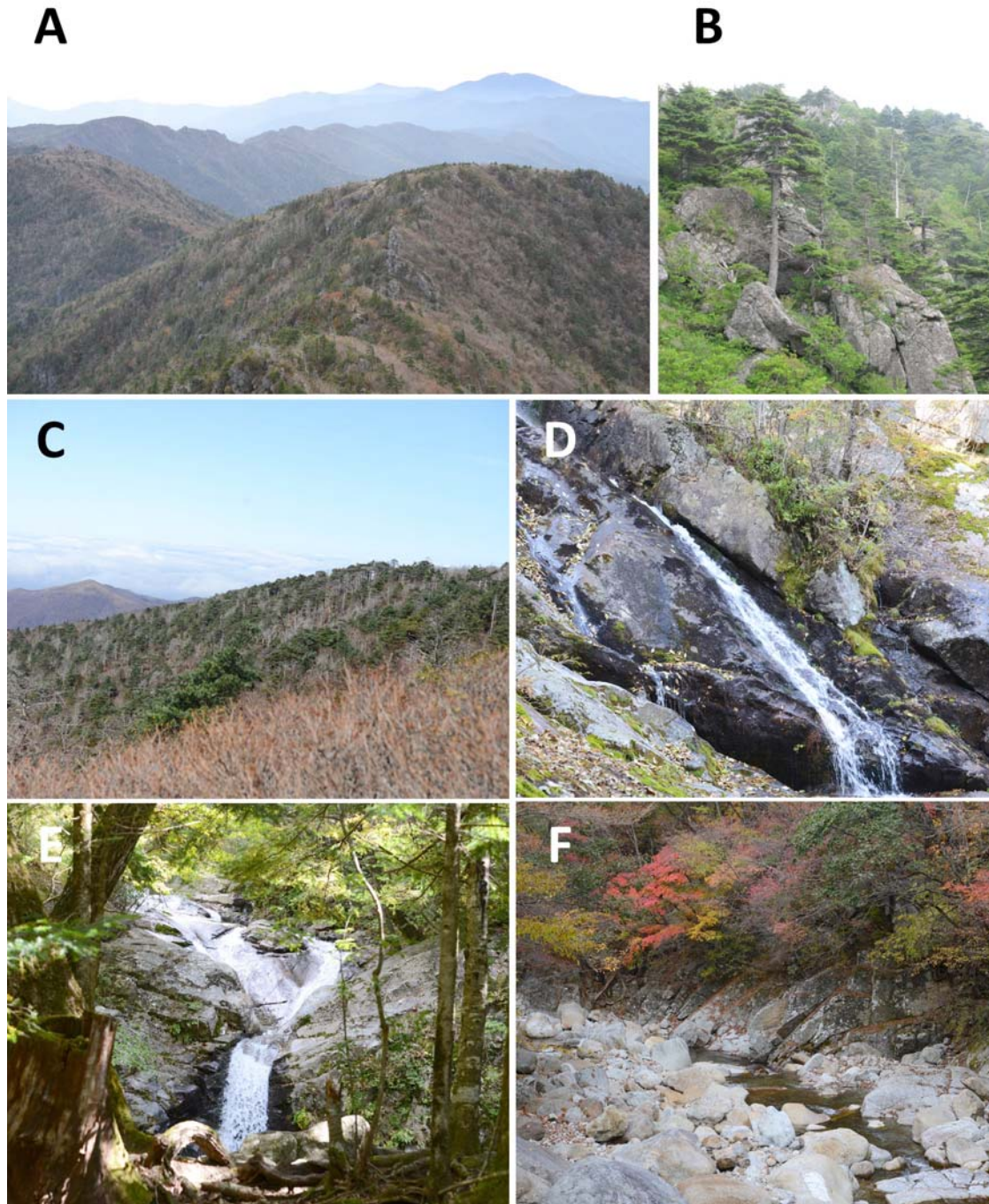


Fig. 2. Landscapes of the Jirisan National Park in Korea. **A.** Main ridge of Cheonwangbong (main peak, 1915 m) – Nogodan (1507 m). **B.** *Abies koreana* forest near peak of Jeseokbong (1808 m). **C.** *Abies koreana* forest near peak of Banyabong (1732 m). **D.** Hansin valley (1350 m). **E.** Chilseon valley. **F.** Baemsagol valley (1100 m). Photos: S.S.Choi.

Yamada (2009) published a checklist that included 79 species known in the park, 16 of which were first records. During the same year, the authors of the present account started a floristic exploration of the area. Bakalin *et al.* (2009) described *Tritomaria koreana* as new to science; the species occupies an isolate position in *Lophozia* (Bakalin *et al.*, 2021a). Choi *et al.* (2012) reported five taxa (*Neotrichocolea bissetii*, *Calypogeia angusta*, *Cephalozia massaloi*, *Harpanthus scutatus*, and *Plectrocolea torticalyx*) from the Jirisan National Park that were

new records for the Korean Peninsula. Recently, Bakalin *et al.* (2019) described *Marsupella koreana* and Bakalin *et al.* (2020) described *Solenostoma jirisanense* as new to science. In total, 99 species were recorded from the park, 19 of which were recorded by the authors' team.

METHODS

Field surveys

Our purposeful studies began in 2009 when Choi and Bakalin first visited the park. Subsequently, Choi visited

many localities in the park, as shown in Fig. 1 (see also Supplementary Materials). In total, over 2500 specimens were collected and identified. Most of them are stored in JNU, with some duplicates and Bakalin's originals in VBGI. The specimens were identified by Choi and Bakalin during a special collaborative project.

Latitudinal and longitudinal fractional composition

To analyze of the distribution characteristics of bryophytes, we obtained global distribution data from Bakalin (2010), and Korean distribution information from Choe (1980), Kim & Hwang (1991), and Choi *et al.* (2021).

LIST OF TAXA

The nomenclature applied Söderström *et al.* (2016) with some updates from the recent literature. Each species is annotated by: 1) presence of sexual and asexual reproductive structures in the studied specimens, using the abbreviations spor. – sporogonia, arch. – archegonia, ant. – antheridia, per. – perianthia, gemm. – gemmae; 2) habitat; 3) altitudinal range in the studied area; 4) accompanying taxa; 5) selected voucher specimen numbers (Choi's collections are prefixed by CS; Bakalin's collections are prefixed by VB). New records from the Jirisan Mountains are marked with asterisks. Unconfirmed records are marked with a degree symbol (°).

Acanthocoleus yoshinaganus (S. Hatt.) Kruijt. – on shaded wet rocks; 647–848 m alt.; CS 3646, CS 3651, CS 8122, CS 110662 (JNU).
 **Acrobolbus ciliatus* (Mitt.) Schiffn. – on wet rock near the waterfall; 840–1241 m alt.; CS 8144, CS 8294 (JNU).
 °*Acrolejeunea pusilla* (Steph.) Grolle et Gradst. – This species was reported by Song & Yamamda (2009) but is absent the collections available for us.
A. sandvicensis (Gottsche) Steph. – per.; on shaded dry rocks; 647–1667 m alt.; CS 3607, CS 9550, CS 110667 (JNU).
Anastrophyllum assimile (Mitt.) Steph. – on shaded cliffs; with *Bazzania paravidentula*, *Cheilolejeunea obtusifolia*, *Scapania ampliata*; 1805–1820 m alt.; CS 3779, CS 3783, CS 111164 (JNU).
 **Aneura pinguis* (L.) Dumort. – on wet rocks; 685–1005 m alt.; CS 3932, CS 7368, CS 8187 (JNU).
Appellia endiviifolia (Dicks.) Nebel et D. Quandt – on wet soil; with *Calypogeia tosana*, *Heteroscyphus coalitus*; 685–1667 m alt.; CS 3432, CS 9131 (JNU).
 **Asterella leptophylla* (Mont.) Grolle – arch.; on shaded wet cliffs; 860 m alt.; CS 3675, CS 3676 (JNU).
Bazzania denudata (Lindenb. et Gottsche) Trevis. – on humus and decaying wood; with *Fuscocephaloziopsis lunulifolia*, *Cololejeunea macounii*, *Scapania ampliata*; 840–1840 m alt.; CS 3750, CS 7382, CS 111096 (JNU).
 **B. imbricata* (Mitt.) S. Hatt. – on humus and decaying wood; 1000–1840 m alt.; CS 1911001, CS 111096 (JNU).
 **B. paravidentula* Bakalin – on humus and bark of *Quercus mongolica*; with *Bazzania denudata*, *Scapania ciliata*, *Tetralophozia filiformis*; 840–1820 m alt.; CS 3550, CS 8282, CS 111158 (JNU).
B. tricrenata (Wahlenb.) Lindb. – on humus and decaying wood; with *Diplophyllum taxifolium*, *Scapania ciliata*; 1421–1841 m alt.; CS 3571, CS 8267, CS 111081 (JNU).
 **B. trilobata* (L.) Gray – on humus and decaying wood; with *Douinia plicata*; 840 m alt.; CS 8159 (JNU).

Blepharostoma minor Horik. – on wet rocks; with *Herbertus aduncus*; 840–1421 m alt.; CS 3559, CS 3686, CS 6023, CS 8168, CS 8193 (JNU).
B. trichophyllum (L.) Dumort. – on humus and decaying wood; with *Fuscocephaloziopsis lunulifolia*, *Syzygiella autumnalis*, *Tritomaria exsecta*; 840–1841 m alt.; CS 3798, CS 3833, CS 7269, CS 8164, CS 8263 (JNU).
Calycularia laxa Lindb. et Arnell – on humus and shaded rocks covered with soil; 848–1840 m alt.; CS 3534, CS 8226, CS 111165 (JNU).
Calypogeia angusta Steph. – on decaying wood; 1134 m alt.; CS 3689 (JNU).
C. arguta Nees et Mont. – on shaded soil near roadsides; with *Cephalozia otaruensis*; 749–1300 m alt.; CS 3968, CS 6047 (JNU).
C. orientalis Buczkowska et Bakalin – on humus and decaying wood; 1134–1820 m alt.; CS 3685, CS 3801 (JNU).
 **C. tosana* (Steph.) Steph. – on shaded soil; with *Cephalozia otaruensis*; 840–1667 m alt.; CS 3560, CS 9135 (JNU).
 **Cephalozia bicuspidata* (L.) Dumort. – on shaded soil; 1202–1805 m alt.; CS 4230, CS 111074 (JNU).
C. otaruensis Steph. – on shaded rocks and humus; 860–1840 m alt.; CS 3677, CS 8237, CS 111120 (JNU).
 **Cephalozia divaricata* (Sm.) Schiffn. – on shaded rocks; 1820 m alt.; CS 3786 (JNU).
 **C. hampeana* (Nees) Schiffn. ex Loeske – ant., per.; on shaded rocks; with *Syzygiella autumnalis*; 840–1711 m alt.; CS 4236, CS 8167, CS 8168 (JNU).
C. massaligi (Spruce) Müll. Frib. – on shaded rocks; 1620 m alt.; CS 3748 (JNU).
 **C. microphylla* (Steph.) Douin – spor.; on shaded soil near roadside; 511–1540 m alt.; CS 3726, CS 6002 (JNU).
C. spinicaulis Douin – on soil and wet rocks; 144–1835 m alt.; CS 3601, CS 111087, CS 111157 (JNU).
 **C. spinigera* (Lindb.) Jørg. – on shaded rocks; with *Syzygiella autumnalis*, *Microlejeunea ulicina*; 1840 m alt.; CS 8232 (JNU).
 **C. varians* (Gottsche) Steph. – on shaded rocks; 1713 m alt.; CS 111062b, CS 111070b (JNU).
Cheilolejeunea obtusifolia (Steph.) S. Hatt. – on wet rocks and shaded rocks; 685–1667 m alt.; CS 3629, CS 7372, CS 111046 (JNU).
Chiaetocaulon mayebarae (S. Hatt.) S.D.F.Patzak, M.A.M. Renner, Schäf.-Verw. & Heinrichs – on rocks covered thin soil near the stream; 1667 m alt.; CS 9132 (JNU).
 **Chiloscyphus pallescens* (Ehrh.) Dumort. – on wet rocks; 969–1667 m alt.; CS 3553, CS 9322 (JNU).
C. polyanthos (L.) Corda – on wet rocks; 1427 m alt.; CS 3533, CS 8273, CS 111126 (JNU).
 **Cololejeunea longifolia* (Mitt.) Benedix ex Mizut. – on shaded rocks; 685–1667 m alt.; CS 3696, CS 7357, CS 9127 (JNU).
 **C. macounii* (Spruce) A. Evans – on shaded rocks; 860–1808 m alt.; CS 3681, CS 8248 (JNU).
 **Conocephalum japonicum* (Thunb.) Grolle – on shaded soil and rocks; 749–781 m alt.; CS 3971, CS 3991 (JNU).
 **C. salebrosum* Szweyk., Buczk. et Odrzyk. – ant.; on shaded rocks; 511–1427 m alt.; CS 3613, CS 8152 (JNU).
 °*Cryptolophocolea compacta* (Mitt.) L. Söderstr. – This species was reported by Hattori *et al.* (1962) but is absent the collections available for us.
 **Cylindrocolea kiaeri* (Austin) Váňa – on shaded rocks; with

- Herbertus aduncus*; 848–1200 m alt.; CS 1910844 (JNU).
- **C. recurvifolia* (Steph.) Inoue – on shaded wet rocks; with *Cheilolejeunea obtusifolia*, *Plicanthus birmensis*; 848 m alt.; CS 3634, CS 3635 (JNU).
- Diplophyllum albicans* (L.) Dumort. – on humus layer over rocks; with *Anastrophyllum assimile*, *Blepharostoma trichophyllum*, *Cephaloziella hampeana*, *Odontoschisma grosseverrucosum*, *Scapania irrigua*; 840–1841 m alt.; CS 3521, CS 8271, CS 111148 (JNU).
- **D. taxifolium* (Wahlenb.) Dumort. – on humus and shaded rocks; 1667–1820 m alt.; CS 3836, CS 9126 (JNU).
- Douinia plicata* (Lindb.) Konstant. et Vilnet – per., spor.; on shaded rocks and shaded humus; 904–1820 m alt.; CS 3791, CS 8249, CS 111166 (JNU).
- **Drepanolejeunea angustifolia* (Mitt.) Grolle – on shaded rocks; with *Frullania appendiculata*; 1793 m alt.; CS 8214 (JNU).
- Frullania appendiculata* Steph. – on bark of tree, decaying wood, dry rocks and shaded rocks; with *Bazzania denudata*, *Metzgeria lindbergii*, *Metzgeria temperata*, *Nipponolejeunea pilifera*, *Scapania ampliata*; 658–1840 m alt.; CS 6026, CS 9890, CS 111159 (JNU).
- F. davurica* Hampe ex Gottsche, Lindenb. et Nees – ant., per.; on bark of *Quercus mongolica* and decaying wood; with *Frullania appendiculata*; 658–820 m alt.; CS 4219, CS 7374, CS 7537, CS 8121 (JNU).
- F. densiloba* Steph. ex A. Evans – on dry rock; with *Microlejeunea ulicina*; 578–1585 m; CS 3640, CS 3825, CS 6011 (JNU).
- F. diversitexta* Steph. – on dry rocks and shaded rocks; 658–860 m; CS 3608, CS 3625, CS 3639, CS 3643, CS 7267, CS 8114 (JNU).
- °*F. ericoides* (Nees) Mont. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.
- °*F. fauriana* Steph. – This species was reported by Uno and Takahashi (1940), Hong (1960), Song and Yamada (2009) but is absent the collections available for us.
- F. hamatiloba* Steph. – on bark of *Malus sieboldii* and bark of *Fraxinus sieboldiana*; 1337 m alt.; CS 7545, CS 7546 (JNU).
- **F. inflata* Gottsch. – on bark of tree; 700–800 m alt.; CS 1910127 (JNU).
- F. kagoshimensis* Steph. – per.; on bark of tree; with *Frullania appendiculata*, *Microlejeunea ulicina*; 842–1820 m alt.; CS 3796, CS 7561 (JNU).
- F. muscicola* Steph. – per.; on dry rock and bark of *Carpinus laxiflora*; 578–1585 m alt.; CS 3603, CS 111145 (JNU).
- °*F. parvistipula* Steph. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.
- **F. pedicellata* Steph. – per.; on bark of *Quercus mongolica*; with *Frullania kagoshimensis*; 1202 m alt.; CS 4208 (JNU).
- **F. polyptera* Taylor – on bark of *Quercus mongolica*; with *Acrolejeunea sandvicensis*; 658–1202 m alt.; CS 4205, CS 8108 (JNU).
- F. schensiana* C. Massal. – on bark of *Quercus mongolica*; with *Frullania muscicola*; 1000–1320 m alt.; CS 1910651 (JNU).
- F. taradakensis* Steph. – on bark of trees; 685–1337 m; CS 7375, CS 7536, CS 7548 (JNU).
- F. usamiensis* Steph. – per.; on bark of *Quercus mongolica*; with *Frullania muscicola*; 685–1820 m alt.; CS 3767, CS 7543, CS 7544 (JNU).
- **Fuscocephaloziopsis catenulata* (Huebener) Vána & L. Söderstr. subsp. *nipponica* (S. Hatt.) Vána et L. Söderstr. – decay-
ing wood; with *Metacalypogeia cordifolia*, *Schistochilopsis cornuta*; 969–1841 m alt.; CS 7380, CS 8265 (JNU).
- F. leucantha* (Spruce) Vána et L. Söderstr. – on decaying wood; with *Fuscocephaloziopsis lunulifolia*; 1808–1841 m alt.; CS 8260, CS 8266 (JNU).
- **F. lunulifolia* (Dumort.) Vána et L. Söderstr. – on decaying wood; with *Blepharostoma trichophyllum*, *Calypogeia arguta*, *Cephalozia bicuspidata*, *Kurzia makinoana*; 969–1835 m alt.; CS 3838, CS 4230, CS 8188, CS 111069, CS 111090 (JNU).
- **Gymnomitrium commutatum* (Limpr.) Schiffn. – on shaded rocks; with *Anastrophyllum assimile*, *Cephaloziella spinicaulis*, *Diplophyllum albicans*, *Microlejeunea ulicina*, *Tetralophozia filiformis*; 1820 m alt.; CS 3778, CS 3827 (JNU).
- G. parvitextum* (Steph.) Mamontov, Konstant. et Potemkin. – on shaded rocks; 1820 m alt.; CS 3816 (JNU).
- °*Harpanthus flotovianus* (Nees) Nees – This species was reported by Choe (1980) but is absent the collections available for us.
- H. scutatus* (F. Weber et D. Mohr) Spruce – on decaying wood in broad-leaved forest with admixture of conifers and shrubs; with *Tritomaria exsecta*; 1720 m alt.; CS 3763a (JNU).
- **Hattorianthus erimonus* (Steph.) R.M.Schust. et Inoue – on wet humus near stream; 685 m alt.; CS 7352, CS 7360 (JNU).
- Herbertus aduncus* (Dicks.) Gray – on shaded rocks; with *Nipponolejeunea pilifera*; 658–1840 m alt.; CS 6015, CS 111088, CS 111146 (JNU).
- **H. buchii* Juslén – on shaded rocks; 1317 m alt.; CS 7556 (JNU).
- **H. dicranus* (Gottsche, Lindenb. et Nees) Trevis. – on shaded rocks; 1500–1820 m alt.; CS 3728, CS 3813, CS 3850 (JNU).
- **Heteroscyphus coalitus* (Hook.) Schiffn. – on wet soil; 842 m alt.; CS 6019 (JNU).
- **H. planus* (Mitt.) Schiffn. – on wet rocks covered soil; with *Calypogeia tosana*, *Solenostoma pyriferum*, *Trichocoleopsis ssacculata*; 840 m alt.; CS 8148 (JNU).
- **Jubula hutchinsiae* (Hook.) Dumort. subsp. *javanica* (Steph.) Verd. – on wet rocks; 860–1421 m alt.; CS 3550, CS 3665 (JNU).
- **J. hutchinsiae* (Hook.) Dumort. subsp. *japonica* (Steph.) Horik. et Ando – on wet rocks near the stream; 1241 m alt.; CS 8276 (JNU).
- **Jungermannia atrovirens* Dumort. – on wet rocks; 1118–1440 m alt.; CS 3679, CS 3716, CS 110665 (JNU).
- **J. exsertifolia* Steph. – on wet rocks; 578 m alt.; CS 3900 (JNU).
- **Kurzia makinoana* (Steph.) Grolle – on rocks covered with soil; with *Blepharostoma minus*, *Cephaloziella hampeana*, *Herbertus aduncus*; 820–1820 m alt.; CS 3782, CS 8125 (JNU).
- Lejeunea compacta* (Steph.) Steph. – on humus; with *Lejeunea parva*, *Lophocolea minor*; 658 m alt.; CS 8112 (JNU).
- L. japonica* Mitt. – per., spor.; on wet rocks; with *Chiloscyphus polyanthus*, *Dicranolejeunea yoshinagana*; 647–1667 m alt.; CS 3621, CS 9948, CS 110660 (JNU).
- **L. parva* (S. Hatt.) Mizut. – on dry rocks; with *Cephaloziella spinicaulis*; 658–1427 m alt.; CS 3604, CS 6007, CS 8117 (JNU).
- **Lepidozia reptans* (L.) Dumort. – on decaying wood; with *Fuscocephaloziopsis leucantha*, *Fuscocephaloziopsis lunulifolia*, *Cephalozia otaruensis*, *Metacalypogeia cordifolia*, *Mylia verrucosa*, *Riccardia multifida* subsp. *decrescens*, *Xenochila integrifolia*; 1118–1841 m alt.; CS 8270, CS 111167 (JNU).

- **L. subtransversa* Steph. – on rocks covered with humus; 840–1808 m alt.; CS 6077, CS 8138, CS 8255 (JNU).
- **L. vitrea* Steph. – on decaying wood; 1713 m alt.; CS 111066 (JNU).
- °*Liochlaena subulata* (A. Evans) Schljakov – This species was reported by Hattori *et al.* (1962) but is absent the collections available for us.
- **Lophocolea heterophylla* (Schrad.) Dumort. – on decaying wood and wet rocks; 685–1720 m alt.; CS 3552, CS 7371 (JNU).
- **L. horikawana* S. Hatt. – on shaded rocks; 842–1720 m alt.; CS 3749, CS 8183, CS 111064 (JNU).
- L. minor* Nees – gemm.; on shaded rocks; 144–1134 m alt.; CS 3623, CS 8172 (JNU).
- **Lophozia guttulata* (Lindb. et Arnell) A. Evans – on decaying wood; with *Calypogeia tosana*, *Tritomaria exsecta*; 1820–1841 m alt.; CS 3798, CS 8265 (JNU).
- L. koreana* (Bakalin, S.S. Choi et B.-Y. Sun) Maltseva, Vilnet et Bakalin – on shaded cliffs; with *Bazzania denudata*, *Fuscocephaloziopsis lunulifolia*, *Douinia plicatum*, *Scapania ampliata*; 1808–1840 m alt.; CS 8225, CS 8254 (JNU).
- **Lophozia excisa* (Dicks.) Konstant. et Vilnet – on decaying wood; 1000–1134 m alt.; CS 1910198 (JNU).
- **Makinoa crispata* (Steph.) Miyake – on wet humus; 685–1421 m alt.; CS 3552, CS 7350, CS 7359 (JNU).
- °*Marchantia paleacea* Bertol. – This species was reported by Song & Yamada (2009), but is absent in our collections.
- **M. paleacea* Bertol. subsp. *diptera* (Nees et Mont.) Inoue – on shaded rocks; 1427 m alt.; CS 5035, CS 5040 (JNU).
- M. polymorpha* L. subsp. *ruderalis* Bischl. et Boissel.-Dub. – gemm.; on shaded soil; 1427 m alt.; CS 5041 (JNU).
- Marsupella apertifolia* Steph. – per.; on shaded rocks; 1300–1720 m alt.; CS 3766, CS 6090 (JNU).
- M. koreana* Bakalin et Fedosov – on cliffs; 1440–1500 m alt.; CS 3058 (JNU).
- M. pseudofunkii* S.Hatt. – ant.; on shaded rocks; 1440–1720 m alt.; CS 3717, CS 40866 (JNU).
- M. tubulosa* Steph. – on wet rocks; with *Cephaloziella hampeana*, *Lejeunea parva*, *Trichocoleopsis sacculata*, *Tritomaria exsecta*; 840–1820 m alt.; CS 3641, CS 8172, CS 111147 (JNU).
- M. yakushimensis* (Horik.) S.Hatt. – on shaded rocks; 840–1805 m alt.; CS 3628, CS 7278, CS 111166 (JNU).
- **Metacalypogeia cordifolia* (Steph.) Inoue – on soil and wet rocks; with *Bazzania denudata*, *Blepharostoma trichophyllum*, *Fuscocephaloziopsis catenulata* subsp. *nipponica*, *Lepidozia reptans*, *Tritomaria exsecta*; 658–1840 m alt.; CS 3602, CS 8245, CS 111107 (JNU).
- Metzgeria furcata* (L.) Corda – on rocks, bark of trees and wet rocks; with *Lejeunea parva*; 860–1808 m alt.; CS 3682, CS 8277 (JNU).
- M. lindbergii* Schiffn. – on bark of trees; 685 m alt.; CS 7354, CS 7370 (JNU).
- M. pubescens* (Schrank) Raddi – on shaded humus; 578–1835 m alt.; CS 3917, CS 111091 (JNU).
- M. temperata* Kuwah. – on rocks; with *Cheilolejeunea obtusifolia*; 848–1835 m alt.; CS 8197, CS 111085 (JNU).
- **Microlejeunea ulicina* (Taylor) Steph. – on base of *Abies koreana*; with *Syzygiella autumnalis*; 720–1700 m alt.; CS 3605, CS 7547 (JNU).
- **Mylia taylorii* (Hook.) Gray – on humus; 1840–1841 m alt.; CS 8233, CS 8238, CS 8264 (JNU).
- **M. verrucosa* Lindb. – on decaying wood; with *Bazzania denudata*, *Bazzania trilobata*, *Fuscocephaloziopsis catenulata* subsp. *nipponica*; 840–1841 m alt.; CS 6049, CS 6051, CS 8269 (JNU).
- Nardia assamica* (Mitt.) Amakawa – on shaded soil near road; 625–1711 m alt.; CS 4217, CS 7571 (JNU).
- Neotrichocolea bissetii* (Mitt.) S.Hatt. – on wet rocks; with *Scapania undulata*, *Trichocoleopsis sacculata*; 996–1793 m alt.; CS 6059, CS 8295 (JNU).
- Nipponolejeunea pilifera* (Steph.) S.Hatt. – on bark of *Abies holophylla* and shaded dry rocks; with *Frullania appendiculata*, *Frullania schensiana*, *Plagiochila porelloides*, *Radula cavifolia*; 1202–1915 m alt.; CS 3573, CS 8231, CS 111086 (JNU).
- Nowellia curvifolia* (Dicks.) Mitt. – on decaying wood near the stream; with *Cephalozia otaruensis*, *Odontoschisma denudatum*; 820–1241 m alt.; CS 8123, CS 8288 (JNU).
- **Odontoschisma denudatum* (Nees) Dumort. – on decaying wood; 658 m alt.; CS 8115 (JNU).
- **O. pseudogrosseverrucosum* Gradst., S.C.Aranda et Vanderp. – on decaying wood and shaded rocks; with *Fuscocephaloziopsis lunulifolia*, *Syzygiella autumnalis*, *Diplophyllum taxifolium*, *Marsupella pseudofunkii*, *Solenostoma pyriformum*; 1317–1915 m alt.; CS 3831, CS 8219 (JNU).
- **Pedinophyllum truncatum* (Steph.) Inoue – per.; on humus and wet rocks; 511–842 m alt.; CS 3608, CS 7338 (JNU).
- **Pellia neesiana* (Gottsche) Limpr. – on wet rocks; 842–1327 m alt.; CS 3694, CS 111132 (JNU).
- Plagiochila gracilis* Lindenb. et Gottsche – on shaded rocks; 1840 m alt.; CS 8234 (JNU).
- **P. hakkodensis* Steph. – on shaded rocks; 1820 m alt.; CS 3818 (JNU).
- P. ovalifolia* Mitt. – ant., per.; on shaded wet rocks; with *Cololejeunea macounii*; 647–1667 m alt.; CS 3615, CS 8153, CS 111130 (JNU).
- °*P. parvifolia* Lindenb. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.
- P. porelloides* (Torr. ex Nees) Lindenb. – on wet rocks; 685–1319 m alt.; CS 3680, CS 8202 (JNU).
- P. sciophila* Nees – on shaded rocks; 860–1134 m alt.; CS 3660, CS 110664 (JNU).
- P. semidecurrens* (Lehm. et Lindenb.) Lindenb. – on shaded rocks; 1700–1800 m alt.; VB Kor-75-2-19 (VBGI).
- **P. trabeculata* Steph. – on shaded rocks; 1700–1820 m alt.; CS 3811, CS 3831 (JNU).
- Plectocolea erecta* Amakawa – per.; on shaded rocks near the stream; 904–1300 m alt.; CS 6066, CS 8192 (JNU).
- P. infusca* Mitt. – per.; on wet rocks covered thin soil; 689–1222 m alt.; CS 3515, CS 3919 (JNU).
- **P. infusca* Mitt. var. *recondita* Bakalin – on wet rocks covered with thin soil; 1202–1300 m alt.; CS 3855, CS 4247 (JNU).
- P. ovalifolia* (Amakawa) Bakalin et Vilnet – on wet rocks covered with thin soil; 1134–1222 m alt.; CS 3702a, CS 3522 (JNU).
- P. rosulans* (Steph.) S.Hatt. – on wet rocks covered with thin soil layer; with *Radula constricta*, *Scapania undulata*; 685–1319 m alt.; CS 3618, CS 8289 (JNU).
- P. torticalyx* (Steph.) S.Hatt. – on wet rocks near the stream in broad-leaved forest; 1300–1900 m alt.; CS 3093, CS 3856 (JNU).
- P. virgata* Mitt. – on wet rocks covered with thin soil layer; 860–1134 m alt.; CS 3659, CS 3697 (JNU).
- Plicanthus birmensis* (Steph.) R.M.Schust. – on shaded rocks;

- with *Cephaloziella spinigera*; 658–1840 m alt.; CS 3636, CS 3644, CS 8235 (JNU).
- **Porella acutifolia* (Lehm. & Lindenb.) Trevis. subsp. *tosana* (Steph.) S. Hatt. – on shaded rocks; 860 m alt.; CS 7270 (JNU).
- P. caespitans* (Steph.) S. Hatt. var. *cordifolia* (Steph.) S. Hatt. ex T. Katag. et T. Yamag. – per.; on shaded rocks; 511–1100 m alt.; CS 3876, CS 3876, CS 7393, CS 8136 (JNU).
- **P. chinensis* (Steph.) S. Hatt. – per.; on shaded rocks; 1000–1100 m alt.; CS 1910624 (JNU).
- P. faurieri* (Steph.) S. Hatt. – on shaded rocks; 1700 m alt.; CS 3841 (JNU).
- P. grandiloba* Lindb. – on shaded rocks; 511–860 m alt.; CS 3884, CS 7369 (JNU).
- P. ulophylla* (Steph.) S. Hatt. – on bark of tree; 647–1700 m alt.; CS 3840, CS 7563, CS 110666 (JNU).
- °*P. japonica* (Sande Lac.) Mitt. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.
- P. vernicosa* Lindb. – on shaded rocks and bark of trees; 860–1711 m alt.; CS 3553, CS 7271, CS 7562 (JNU).
- Protosolenostoma fusiforme* (Steph.) Vilnet et Bakalin – 1421 m alt.; CS 5042 (JNU).
- **Ptilidium pulcherrimum* (Weber) Vain. – spor.; on bark of tree; with *Cephaloziella spinigera*, *Scapania ampliata*; 1820–1840 m alt.; CS 3802, CS 8242 (JNU).
- Radula auriculata* Steph. – on shaded rocks; 685–1820 m alt.; CS 3800, CS 7358 (JNU).
- R. constricta* Steph. – on bark of trees; 1317–1421 m alt.; CS 3551, CS 7551 (JNU).
- R. japonica* Gottsche – on wet rocks; 647–1134 m alt.; CS 3703, CS 110661 (JNU).
- °*R. obtusiloba* Steph. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.
- °*R. oyamensis* Steph. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.
- **R. tokiensis* Steph. – on shaded rocks; with *Lejeunea japonica*, *Metzgeria lindbergii*; 685 m alt.; CS 7340 (JNU).
- Reboulia hemisphaerica* (L.) Raddi – on shaded rocks; 749–1320 m alt.; CS 3709, CS 3967, CS 3973 (JNU).
- °*Riccardia chamedryfolia* (With.) Grolle – This species was reported by Choe (1980) but is absent the collections available for us.
- **R. multifida* subsp. *decreescens* (Steph.) Furuki – on decaying wood; 1300 m alt.; CS 6070 (JNU).
- **R. palmata* (Hedw.) Carruth. – on decaying wood; with *Cephalozia* sp.; 1241–1820 m alt.; CS 3810, CS 8287 (JNU).
- **Scapania ampliata* Steph. – on wet rocks; with *Bazzania denudata*, *Cephaloziella spinigera*, *Solenostoma pyriformum*; 860–1840 m alt.; CS 3688, CS 8234, CS 111152 (JNU).
- **S. apiculata* Spruce – on humus; 1427 m alt.; CS 5038 (JNU).
- **S. ciliata* Sande Lac. – on decaying wood; 749–1667 m alt.; CS 3963, CS 9134 (JNU).
- °*S. curta* (Mart.) Dumort. – This species was reported by Hattori *et al.* (1962) but is absent the collections available for us.
- S. integerrima* Steph. – on wet rocks; with *Plectocolea rosulans*; 842–1540 m alt.; CS 3741, CS 8192 (JNU).
- **S. irrigua* (Nees) Nees – on wet rocks near the stream; with *Metacalypogeia cordifolia*; 1134–1805 m alt.; CS 3690, CS 111162 (JNU).
- **S. paludosa* (Müll. Frib.) Müll. Frib. – on wet soil; with *Makinoia crispata*; 720–1319 m alt.; CS 3614, CS 8209 (JNU).
- **S. parvitexta* Steph. – on shaded rocks; with *Scapania irrigua*, *Scapania integerrima*; 685–1840 m alt.; CS 3609, CS 8231 (JNU).
- **S. subalpina* (Nees ex Lindenb.) Dumort. – gemm.; on wet rocks; 1000–1385 m alt.; CS 1910732 (JNU).
- S. undulata* (L.) Dumort. – gemm.; on wet rocks; 658–1585 m alt.; CS 3555, CS 8292, CS 111144 (JNU).
- **Schistochilopsis cornuta* (Steph.) Konstant. – on decaying wood; with *Bazzania parabidentula*, *Bazzania tricrenata*, *Blepharostoma trichophyllum*, *Fuscocephaloziopsis catenulata* ssp. *nipponica*, *Fuscocephaloziopsis lunulifolia*, *Douinia plicata*; 1100–1840 m alt.; CS 3812, CS 8256, CS 111151 (JNU).
- Solenostoma bilobum* (S. Hatt. ex Amakawa) Potemkin et Nyushko – 1729 m alt.; CS 3762 (JNU).
- S. cyclops* (S. Hatt.) R.M. Schust. – on shaded wet rocks along stream; 860–1319 m alt.; CS 7279, CS 8204 (JNU).
- S. jirisanense* Bakalin et S.S. Choi – on shaded rocks covered thin soil; 1500–1800 m alt.; CS 3747-3 (JNU), VB Kor-25-5-15 (VBGI).
- S. pyriformum* Steph. – on cliff, wet rocks and shaded rocks; with *Scapania integerrima*; 1440–1915 m alt.; CS 3710, CS 6085, CS 8280 (JNU).
- S. rotundatum* Amakawa – on wet rocks covered thin soil; 848 m alt.; CS 3658 (JNU).
- S. sunii* Bakalin et Vilnet – on shaded rocks covered with thin soil layer; 848–1720 m alt.; CS 3653, CS 3759 (JNU).
- **Sphenolobus saxicola* (Schrad.) Steph. – on shaded rocks in stony field; 904 m alt.; CS 8170 (JNU).
- Szygiella autumnalis* (DC.) K. Feldberg, Váňa, Hentschel et Heinrichs – spor.; on wet rocks and dry rocks; with *Bazzania parabidentula*, *Cephaloziella spinigera*, *Diplophyllum taxifolium*, *Metacalypogeia cordifolia*, *Plagiochila gracilis*, *Ptilidium pulcherrimum*, *Tritomaria exsecta*; 685–1915 m alt.; CS 3561, CS 9129, CS 111114 (JNU).
- **Tetralophozia filiformis* (Steph.) Urmi – on shaded cliffs; with *Cephaloziella spinicaulis*, *Diplophyllum taxifolium*, *Herbertus aduncus*, *Odontoschisma pseudogrosseverrucosum*; 840–1835 m alt.; CS 3684, CS 8171, CS 111058 (JNU).
- **Trichocolea tomentella* (Ehrh.) Dumort. – on shaded humus; with *Calypogeia tosana*, *Cephalozia otaruensis*, *Metacalypogeia cordifolia*, *Schistochilopsis cornuta*; 1118 m alt.; CS 6036, CS 6037, CS 6039 (JNU).
- Trichocoleopsis sacculata* (Mitt.) S. Okamura – on rocks; 511–1805 m alt.; CS 3524, CS 7344, CS 111160 (JNU).
- **Trilophozia quinquentata* (Huds.) Bakalin – on shaded rocks; with *Lophozia koreana*, *Scapania ampliata*, *Schistochilopsis cornuta*; 1808 m alt.; CS 6561 (JNU).
- Tritomaria exsecta* (Schmidel) Schiffn. ex Loeske – on wet rocks; with *Bazzania denudata*, *Blepharostoma minus*, *Fuscocephaloziopsis lunulifolia*, *Scapania ampliata*; 781–1808 m alt.; CS 3751, CS 8251 (JNU).
- **Xenochila integrifolia* (Mitt.) Inoue – on shaded wet rocks along stream; 685 m alt.; CS 7342, CS 7362, CS 7364 (JNU).

DISCUSSION

Based on the analysis of 2500 herbarium specimens and a review of data in the literature, we found that the bryophyte flora of the Jirisan Mountains includes 177 taxa, of which 78 species are newly records for the park. There were 14 species recorded in the literature that had no corresponding herbarium specimen. The species *Lopholejeunea subfusca* was excluded from the list of taxa because, although it was reported on the Jirisan Moun-

Table 1. The latitude fractional composition in the hepatics of the Jirisan National Park in Korea; The treatment of floristic elements (latitudinal types) follows to Konstantinova (2000) and Bakalin (2010).

Floristic elements (latitudinal types)	Taxa	Ratio (%)
Arctic	12	6.8
Arctic-boreal	25	14.1
Boreal	18	10.2
Boreal-temperate	19	10.7
Temperate	48	27.1
Temperate-subtropical	31	17.5
Subtropical	13	7.3
Subtropical-tropical	4	2.3
Multizone	7	4.0
Total	177	100

tains by Hong (1962), its distribution is limited to tropical and subtropical areas, so its occurrence on the Jirisan mountains is unlikely (Choi *et al.*, 2021). The plants observed by Hong (1962) most likely belonged to *Acanthocoleus yoshinaganus*. In recent research on the Jirisan Mountain's liverworts, *Lophozia koreana* (Fig. 3D), *Marsupella koreana* (Fig. 3E), and *Solenostoma jirisanense* (Fig. 3F) were recorded as being new to science (Bakalin *et al.*, 2009, 2019, 2020, 2021b). *Lophozia koreana* has subsequently been observed in Japan (Bakalin, 2016), *Marsupella koreana* has been discovered in Daedunsan, Gyaysan, Namdeogyusan, Dureunsan, and Hallasan Mountains in Korea (Bakalin *et al.*, 2021b).

In the analysis of longitudinal distribution characteristics of liverworts, 89 taxa (50.3%) were East Asian, 49 taxa (27.7%) were circumpolar, nine taxa (5.1%) were widespread in Asia, eight taxa (4.5%) were amphioceanic and seven taxa (4.0%) were amphipacific (Table 1). This result is consistent with the Korean Peninsula belonging to the Eastern Asia floristic region defined by Takhtajan (1986). A latitudinal analysis of floristic elements found, 48 taxa (27.1%) were temperate, 31 taxa (17.5%) were temperate-subtropical, 25 taxa (14.1%) were arctic-boreal, 19 taxa (10.7%) were boreal-temperate, 18 taxa (10.2%) were boreal, 13 taxa (7.3%) were

Table 2. The longitudinal fractional composition in the Jirisan National Park in Korea; floristic elements (longitudinal types) follows Konstantinova (2000) and Bakalin (2010).

Area types (longitudinal types)	Taxa	Ratio (%)
Amphioceanic	8	4.5
Amphipacific	7	4.0
Asia	9	5.1
Asian-American	4	2.3
Asian-Euro	2	1.1
Circumpolar	49	27.7
Disjunctive	1	0.6
Eastern Asia	89	50.6
Eastern Asia-American	1	0.6
Multiarea	7	4.0
Total	177	100

Table 3. Altitudinal distribution of all taxa in the Jirisan National Park.

Altitude, m	Species	Ratio (%)
0–500	58	32.7
500–1000	114	64.4
1000–1500	131	74.0
1500–1917	94	53.1

subtropical and 12 (6.8%) were arctic species (Table 2).

The following data on species diversity may show at least roughly a pattern of liverwort distribution along the altitude. As expected, high elevations of over 1000 m a.s.l. comprise the maximal diversity in this area (Table 3). This result is because the altitudes of the Jirisan Mountains ridge are between 1000 and 1500 m a.s.l.

Neotrichocolea bissetii, *Lepidozia subtransversa* and *Nipponolejeunea pilifera* (Fig. 3A, B, G) are rare Korean species recorded from the Jirisan Mountains. *Neotrichocolea bissetii* is endemic to East Asia, and is distributed in China (Anhui, Fujian, Yunnan, Zhejiang Provinces) and Japan (Honshu, Shikoku, and Kyushu Islands). In Korea, it is recorded only in the Jirisan Mountains (Choi *et al.*, 2012). We discovered this species on wet rock near a waterfall on humic soil near N-facing slope near the top of the mountain in broad-leaved forest with *Oplopanax elatus* (Nakai) Nakai, *Acer* sp., *Quercus* sp., and a *Abies koreana* forest. *Lepidozia subtransversa* is restricted to temperate regions of East Asia, including the Korean Peninsula, Japan, China and the southernmost of the Russian Far East (Yamada & Iwatsuki, 2006; Piippo, 1990; Choi & Bakalin, 2012). In Korea, it was previously recorded only in the Jirisan and Seolaksan Mountains. We recorded the species on humus covered rocks, decaying wood near northwestern slopes of a top area and Hansin Stream valley. *Nipponolejeunea pilifera* represents mainly Japanese-Korean oro-hemiboreal to oro-temperate endemic, known from Hokkaido to Kyushu in Japan, Korea, Taiwan, and northwardly known in southern Kurils (Piippo 1990; Yamada & Iwatsuki, 2006; Bakalin, 2019). In Korea, it was previously recorded from Deogyusan, Gayasan, Ullengdo Island (Seonginbong), and the Jirisan Mountains. This species grows in coniferous forests (*Abies koreana*, *A. nephrolepis*), along with *Frullania appendiculata*, *F. usamiensis*, *Radula constricta* and on shaded cliffs together with *Scapania ampliata*, *Anastrophyllum assimile*, and *Marsupella yakushimensis*.

We found the most significant area for liverwort diversity in the Jirisan Mountains – the plant communities of *Abies koreana*, *A. nephrolepis*, and *Oplopanax elatus* located near the northern slope of Cheonwangbong Peak (1915 m a.s.l.), the highest peak of the Jirisan Mountain (Fig. 2A–B). In this area, we found *Lophozia koreana*, *Anastrophyllum assimile*, *Nipponolejeunea pilifera*, *Neotrichocolea bissetii*, *Douinia plicata*, and *Schistochilopsis cornuta*, and some species that are typically found in several subalpine regions of the Korean Peninsula. An-

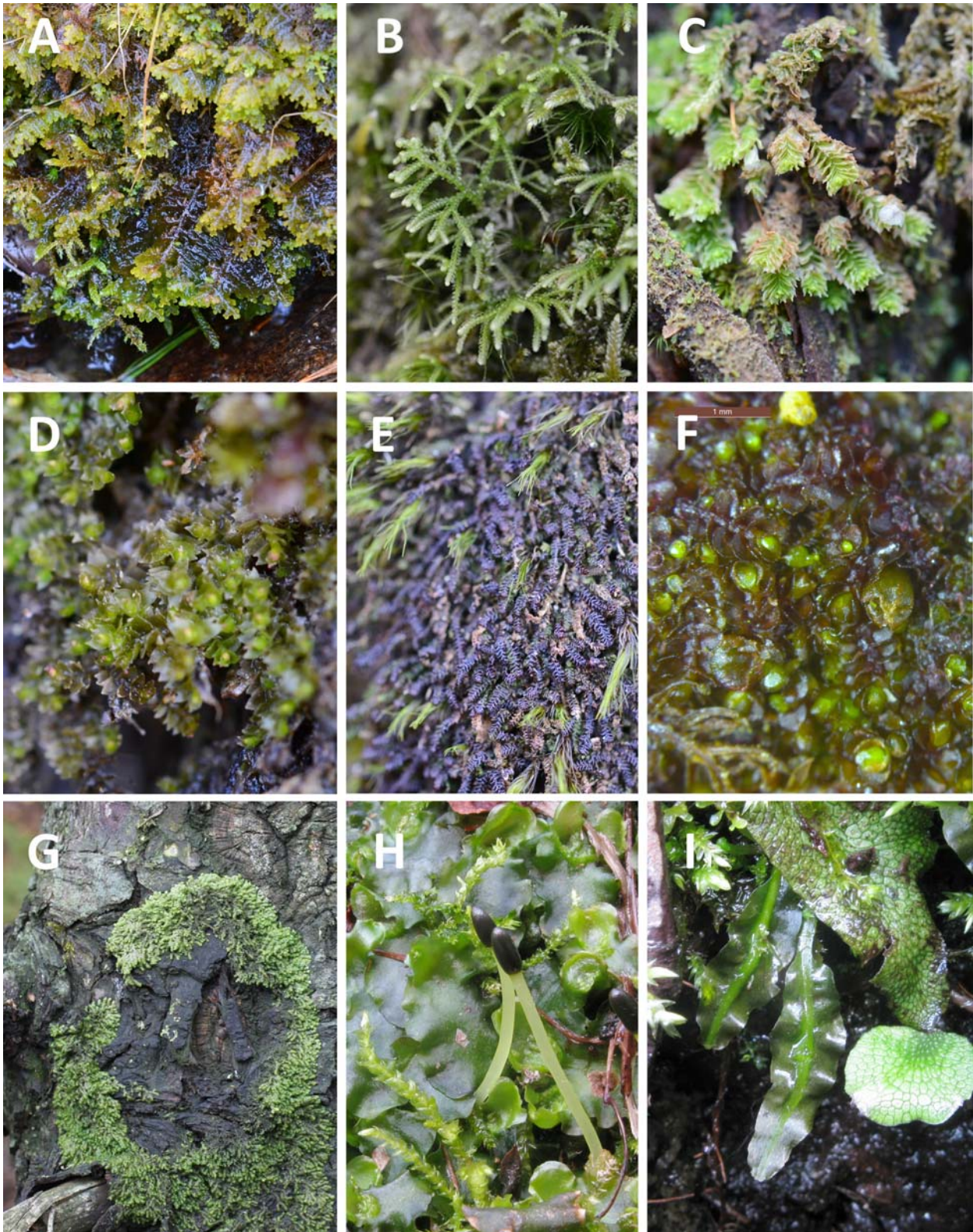


Fig. 3. Some main liverworts of the Jirisan National Park in Korea. **A.** *Neotrichocolea bissetii*. **B.** *Lepidozia subtransversa*. **C.** *Schistochilopsis cornuta*. **D.** *Lophozia koreana*. **E.** *Marsupella koreana*. **F.** *Solenostoma jirisanense*. **G.** *Nipponolejeunea pilifera*. **H.** *Makinoa crispata*. **I.** *Hattorianthus erimonus*. Photos: S.S. Choi.

other area is the upper half of the Hansin Valley, which runs from Seseok Ridge to Hanshin Valley (Fig. 2D). Waterfalls and rock fields on the north slopes of the Seseok Ridge are common. There we found *Lepidozia subtransversa*, *Plectocolea rosulans*, *Scapania ciliata*, *Bazzania imbricata*, *Neotrichocolea bissetii*, *Scapania undulata*, and some additional species recorded from subalpine areas of the Korean Peninsula.

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