LIVERWORT FLORA OF THE JIRISAN NATIONAL PARK IN KOREA

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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.

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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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 km$^2$. The lowland area of the park is populated by broad-leaved deciduous forest that gradually changes into coniferous mountain forest near ridge-lines intermixed with thickets of Magnolia sieboldii K. Kochand 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 temperate 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) subsp. obscura Verd. (= Frullania appendiculata) and Madotheleca 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 &
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*, *Cephaloziella massalogi*, *Harpanthus scutatus*, and *Plectocolea turticar taxis*) 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 Supporting 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 the distribution characteristics of bryophytes, we obtained global distribution data 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. – sporangia, 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 (°).
Herbertus aduncus; 484–1200 m alt.; CS 1910844 (JNU).

*C. recurvfolia* (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*, *Odontoschima grosseverrucosum*, *Scapania irrigua*; 840–1841 m alt.; CS 3521, CS 8271, CS 111448 (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.; 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).

*F. diversitexta* (Huebener) Váňa & L. Söderstr. subsp. *D. taxifolium* (Wahlenb.) Dumort. – on humus 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, Lindenh. et Nees – ant., per.; on bark of *Quercus mongolica* decaying wood with *Frullania appendiculata*; 658–820 m alt.; CS 4219, CS 7374, CS 7537, CS 8121 (JNU).

*F. densiloba* Step. ex A. Evans – on dry rock; with *Microlejeunea ulicina*, *Plicanthus birmensis*; 578–1585 m; CS 3640, CS 3825, CS 6011 (JNU).

*F. diversitexta* Step. – on dry rocks and shaded rocks; 658–860 m; CS 3608, CS 3625, CS 3639, CS 7643, 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* (JNU).

*F. fuscopunctata* Step. – on dry rock and bark of *Carpinus laxiflora*; 578–1585 m; CS 3603, CS 3833, CS 111445 (JNU).

*F. parvistipula* Step. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.

*F. pedicellata* Step. – per.; on bark of *Quercus mongolica*; with *Frullania kagoshimensis*; 1202 m alt.; CS 4208 (JNU).

*F. polygonera* 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 micriscula*; 1000–1320 m alt.; CS 1910651 (JNU).

*F. taradakensis* Step. – on bark of trees; 685–1337 m; CS 7373, CS 7536, CS 7548 (JNU).

*F. usaminensis* Step. – per.; on bark of *Quercus mongolica*; with *Frullania micriscula*; 685–1820 m alt.; CS 3767, CS 7543, CS 7544 (JNU).

*Fuscocephaloziopsis catenulata* (Huebener) Váňa & L. Söderstr. subsp. *nipponica* (S. Hatt.) Váňa et L. Söderstr. – decaying wood; with *Metacalygopgia cordifolia*, *Schistochilopsis cornuta*; 969–1841 m alt.; CS 7380, CS 8265 (JNU).

*F. leucantha* (Spruce) Váňa et L. Söderstr. – on decaying wood; with *Fuscocephaloziopsis lunulifolia*; 1808–1841 m alt.; CS 8260, CS 8266 (JNU).

*F. lunulifolia* (Dumort.) Váňa et L. Söderstr. – on decaying wood; with *Blepharostoma trichophyllum*, *Cephaloziella arguta*, *Cephaloziella bicupulata*, *Kurzia makinoa*; 969–1835 m alt.; CS 3838, CS 4230, CS 8188, CS 110169, CS 111090 (JNU).

*Gymnostomum commutatum* (Limpr.) Schiffn. – on shaded rocks; with *Anastrophyllum assimile*, *Blepharostoma spinicaulis*, *Diplophyllum albicans*, *Microlejeunea ulicina*, *Tezralophoza filiformis*; 1820 m alt.; CS 3778, CS 3827 (JNU).

*G. parviflum* (Steph.) Mamontov, Konstant. et Potemkin. – on shaded rocks; 1820 m alt.; CS 3816 (JNU).

*Herbertus aduncus* (Dicks.) Gray – on shaded rocks; with *Frullania kagoshimensis*; 8276 m alt.; CS 8269 (JNU).

*H. bchui* Juslén – on shaded rocks; 1317 m alt.; CS 7556 (JNU).

*H. dickranus* (Gottsche, Lindenh. 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 *Calypogea tosana*, *Solenostoma pyriflorum*, *Tricholeocopsis scacculata*; 840 m alt.; CS 8148 (JNU).

*Hubula 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).

*Jugennaria atrovirens* Dumort. – on rocks covered soil; 911–1440 m alt.; CS 3679, CS 3716, CS 110665 (JNU).

*J. extersifolia* Step. – on wet rocks; 578 m alt.; CS 3900 (JNU).

*Kurzia makinoa* (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.) – on humus; with *Lejeunea parva*, *Lophocolea minor*; 658 m alt.; CS 8112 (JNU).

*L. japonica* Mitt. – per.; on wet rocks; with *Chiloscyphus polyanthus*, *Dicranolejeunea yoshinagana*; 647–1667 m alt.; CS 3621, CS 9948, CS 110660 (JNU).

*L. parva* (S. Hatt.) Mizut. – per.; on wet rocks; with *Cephaloziella spinicaulis*; 658–1427 m alt.; CS 3604, CS 6007, CS 8117 (JNU).

*Lepidodzia reptans* (L.) Dumort. – on decaying wood; with *Fuscocephaloziopsis leucantha*, *Fuscocephaloziopsis lunulifolia*, *Cephaloziella otarunensis*, *Metacalygopgia cordifolia*, *Mylia verrucosa*, *Riccardia multifida* subsp. *decrescens*, *Xenochila integrifolia*; 1118–1841 m alt.; CS 8270, CS 111167 (JNU).
*Marchantia paleacea* Song & Yamada (2009), but is absent in our collections.

*Marchantia ampliata* (JNU).

*M. koreana* Bakalin – on shaded soil near road; 625–1711 m alt.; *CS 4217, CS 7571* (JNU).

*M. temperata* (Hook.) Gray – on shaded woods; 1840–1841 m alt.; *CS 8123, CS 8288* (JNU).

*M. verrucosa* Lindb. – on shaded wood; with *Bazzania dentulata*, *Buccocephaloziopsis 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).

*N. trichocolea bisetii* (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 pereoides*, *Radula cavitofila*; 1202–1915 m alt.; *CS 3573, CS 8231, CS 11086* (JNU).

*N. nipponica* Bakalin – on shaded cliffs; with *Marchantia paleacea*, *Marchantia ampliata*; 820–1241 m alt.; *CS 8202, CS 8203* (JNU).

*odontoschisma dentulatum* (Nees) Dumort. – on shaded rocks; 658–1840 m alt.; *CS 3694, CS 111332* (JNU).

*Plagiochila gracilis* Lindenb. et Gottsche – on shaded rocks; 840 m alt.; *CS 8234* (JNU).

*P. ovatifolia* Mitt. – on shaded rocks; 1820 m alt.; *CS 3818* (JNU).

*P. ovatifolia* Mitt. – on shaded rocks; with *Cololejeunea macounii*; 647–1667 m alt.; *CS 3615, CS 8153, CS 11130* (JNU).

*P. parvifolia* Lindenb. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.

*P. pereoides* (Torr. ex Nees) Lindenb. – on wet rocks; 685–1319 m alt.; *CS 3680, CS 8202* (JNU).

*P. sciolphiodes Nees – on shaded rocks; 680–1134 m alt.; *CS 3660, CS 110864* (JNU).

*P. semidecurrens* (Lehm. et Lindenb.) Lindenb. – on shaded rocks; 1700–1800 m alt.; *VB Kor-75-2-19* (VBGI).

*P. trabeuculata* Steph. – on shaded rocks; 1700–1820 m alt.; *CS 3811, CS 3831* (JNU).

*Plucaecorea erecta* Amakawa – on shaded rocks near the stream; 904–1300 m alt.; *CS 6066, CS 8192* (JNU).

*P. fusca* Mitt. – per.; on wet rocks covered thin soil; 689–1222 m alt.; *CS 3515, CS 8191* (JNU).

*P. infusa* Mitt. var. *recondita* Bakalin – on wet rocks covered with thin soil; 1202–1300 m alt.; *CS 3835, CS 4247* (JNU).

*P. ovatifolia* (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. tormicalyx* (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 thick soil layer; 860–1134 m alt.; *CS 3659, CS 3697* (JNU).

*Plicanthus birmensis* (Steph.) R.M.Schust. – on shaded rocks;
with Cephalozia 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. caespitians* (Steph.) S. Hatt. var. *cordifolia* (Steph.) S. Hatt. ex T.Katat. 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. grandifolia* Lindb. – on shaded rocks; 511–860 m alt.; CS 3884, CS 7369 (JNU).

*P. ulophylla* (Steph.) Grolle – This species was reported by Song & R. oyamensis (JNU).

*P. vernicosa* (Steph.) Mitt. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.

*P. vaginosa* 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.; CS5042 (JNU).

*Ptilidium pulcherrimum* (Weber) Vain. – spor.; on bark of tree; with Cephalozia 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 7351 (JNU).

R. japonica Gottsch. – on wet rocks; 647–1134 m alt.; CS 3703, CS 3708, CS 110666 (JNU).

*R. obtusiloba* Steph. – This species was reported by Song & Yamada (2009) but is absent the collections available for us.

*R. oymensis* 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).

Reboula 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 Cho (1980) but is absent the collections available for us.

*R. multifida* subsp. *decrescens* (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, Cephalozia spinigera, Selenostoma pyriformum; 860–1840 m alt.; CS 3688, CS 8234, CS 111152 (JNU).

*S. apiculata* Spruce – on humus; 1427 m alt.; CS 7308 (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 Hattoni et al. (1962) but is absent the collections available for us.

*S. intergerima* Steph. – on wet rocks; with Plectocolea rosulans; 842–1540 m alt.; CS 3741, CS 8192 (JNU).

*S. irriga* (Nees) Nees – on wet rocks near the stream; with Metacalygojega cordifolia; 1134–1805 m alt.; CS 3690, CS 111162 (JNU).

*S. paludosa* (Müll. Frib.) Müll. Frib. – on wet soil; with Makino crispsata; 720–1319 m alt.; CS 3614, CS 8209 (JNU).

*S. parviflora* Steph. – on shaded rocks; with Scapania irrigua, Scapania integrerrima; 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).

*Schiectchiolopsis cornuta* (Steph.) Konstant. – on decaying wood; with Bazzania parabidentulenta, 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.; CS1762 (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 clff, wet rocks and shaded rocks; with Scapania integrerrima; 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, CS3759 (JNU).

*Sphenolobus saxicola* (Schrad.) Steph. – on shaded rocks in stony field; 904 m alt.; CS 8170 (JNU).

Szczygilla autumnalis (DC.) K. Feldberg, Vána, Hentschel et Heinrichs – spor.; on wet rocks and dry rocks; with Bazzania parabidentulenta, Cephalozia spinigera, Diplophyllum taxifolium, Metacalygojega cordifolia, Plagiochila gracilis, Pilidium pulcherrimum, Tritomaria exsecta; 685–1915 m alt.; CS 3561, CS 9129, CS 111114 (JNU).

*Tetrathele planicollis* (Steph.) Urmi – on shaded cliffs; with Cephalozia spinicaulis, Diplophyllum taxifolium, Herbstia aduncus, Odontoschisma pseudogrosserevussocorum; 840–1835m alt.; CS 3684, CS 8171, CS 110158 (JNU).

*Trichocolea tomentella* (Ehrh.) Dumort. – on shaded humus; with Calypogea tosana, Cephalozia otaruenesis, Metacalygojega cordifolia, Schistochilopsis cortula; 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 quinquedentata* (Huds.) Bakalin – on shaded rocks; with Lophozia koreana, Scapania ampliata, Schischchiolopsis cornuta; 1808 m alt.; CS 6631 (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 recorded for the park. There were 14 species recorded in the literature that had no corresponding herbarium specimen. The species *Lophozia koreana* was excluded from the list of taxa because, although it was reported on the Jirisan Moun-
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 yoshinaguanus. 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 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 bissetti**, *Lepidozia subtransversa* and *Nipponolejeunea pilifera* (Fig. 3A, B, G) are rare Korean species recorded from the Jirisan Mountains. *Neotrichocolea bissetti* is endemic to East Asia, and is distributed in China (Anhui, Fujian, Yunnan, Zhejing 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; Pippio, 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 (Pippio 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 bissetti, Douinia plicata*, and *Schistochilopsis cornuta*, and some species that are typically found in several subalpine regions of the Korean Peninsula. An-

| 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       |

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

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).

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

Table 3. Altitudinal distribution of all taxa in the Jirisan National Park.
Fig. 3. Some main liverworts of the Jirisan National Park in Korea. A. Neotrnochocolea 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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