Lichens from Mugikusa Pass and the Adjacent Areas in Kita-Yatsugatake Mts, Central Japan

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Abstract Lichens of Mugikusa Pass and the adjacent areas in Kita-Yatsugatake Mountains, central Japan, were surveyed from 2011 to 2018. As the result of taxonomic examinations of 390 out of 442 specimens, 146 taxa (145 species 1 subspecies 1 variety) in 64 genera were recognized. The 141 ITS rDNA sequences were successfully obtained from 84 species. Among them, *Menegazzia caviisidia* and *Usnea longissima* are known as the species of "Near Threatened (NT)" category in the Red List 2020 of Ministry of the Environment, Government of Japan; *Baeomyces carneus* and *Cetrelia cetrarioides* were insufficiently understood in Japan; and *Peltigera neopolydactyla* and *Rhizocarpon hochstetteri* are species requiring further taxonomic examination. These species were discussed in detail in the species list.

Keywords: DNA barcoding, inventory, ITS rDNA, lichenized fungi, mycota, subalpine, taxonomy.

Introduction

Kita-Yatsugatake Mountains is located to the northern part of the Yatsugatake Mountains in central Japan. The forests consist of subalpine vegetation such as *Abies mariesii* Masters, *A. veitchii* Lindl., *Betula ermanii* Cham., and *Tsuga diversifolia* (Maxim.) Mast. with several alpine plants, e.g., Vaccinium vitis-idaea L., Schizocodon soldanelloides Siebold et Zucc. and *Geum calthifolium* Menzies ex Sm. var. *nipponicum* (F.Bolle) Ohwi, found on rocky areas (Shimizu, 1997). Due to the richness of bryophyte, the area around Shirakoma Pond is designated as National Bryophyte Heritage Sites in Japan by the Bryological Society of Japan (Higuchi, 2010). Little is known about lichens in this area, but several species were reported in scattered papers (e.g., Kashiwadani, 1975; Inoue, 1983; Miy-awaki, 1988; Ohmura, 2012, 2016, 2020; Frisch *et al.*, 2022).

The purpose of this study was to inventory the lichens of Mugikusa Pass and the adjacent areas in Kita-Yatsugatake Mountains based on the authors' collections and discuss about threatened species, insufficiently understood species in Japan, and species requiring further taxonomic examination. ITS rDNA sequences were generated from some identified specimens.

Materials and Methods

Field surveys were carried out by the authors from 2011 to 2018, and 442 specimens were collected from the study area. Collection sites are showing in Fig. 1 and Table 1. The detail information of identified specimens are shown in Supplement 1 in

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Fig. 1. Map showing investigated sites in Mugikusa Pass and the adjacent areas in Kita-Yatsugatake Mts, central Japan. Each investigated site is indicated by dash line circle with locality ID.

J-STAGE Data. All voucher specimens are housed in the herbarium of the National Museum of Nature and Science (TNS), Tsukuba, Japan.

Morphological observations were made using a dissecting microscope (Olympus SZX16) and a differential interference contrast microscope (Olympus BX53). Anatomical examinations were made on hand cut sections mounted in water. Ascospore measurements are given as (minimum–) range including mean \pm standard deviation (–maximum) (n = number of measurements).

Color spot tests with K, C, KC, and Pd were performed following Orange *et al.* (2001).

Chemical substances of lichens were examined using thin layer chromatography (TLC) (Culberson and Johnson, 1982). Solvent system B' (hexane : methyl tert-butyl ether : formic acid, 140 : 72 : 18) was used for all TLC analyses.

DNA extraction followed a modified CTAB protocol (Hosaka, 2009).

For DNA amplification, $10\,\mu$ L of PCR mix contained $1\,\mu$ L genomic DNA extraction, $0.25\,\mu$ L of each primer (10 pmol/ μ L) and $5\,\mu$ L Emerald-Amp PCR Master Mix (TaKaRa Bio Inc.). PCR amplification of the ITS rDNA region (including ITS1, 5.8S rDNA and ITS2) was performed using the primer set of ITS1F (Gardes and Bruns, 1993) as the 5' primer and LR1 (Vilgalys and Hester, 1990) as the 3' primer. PCR cycling conditions were 94°C (3 min), followed by 11 cycles of 95°C (30 sec), 62°C to 52°C (30 sec) with annealing temperatures lowered by 1°C between cycles, and 72°C (1 min), followed by 30 cycles at 52°C annealing temperature and a final extension at 72°C (7min). In some cases, when no PCR product was appeared by ITS1F/LR1 primer pair, USITS1-F as the 5' primer and USITS2-R as the 3' primer (Ohmura, 2008), were used for the PCR. The PCR protocol was the same above mentioned. Sequencing was done on an ABI Prism 3130x genetic analyzer (Applied Biosystems) using the BigDye Terminator ver. 3.1 Cycle Sequencing Kit according to the manufacturer's instructions.

Results and Discussion

As the result of taxonomic examinations of 390 out of 442 specimens collected within the study area, 146 taxa (145 species 1 subspecies 1 variety) in 64 genera were recognized. The rest 52 specimens could not be identified for species including the following genera (e.g., *Arthonia*, *Candelariella*, *Chrysothrix*, *Gyalolechia*, *Lecanora*, *Lepra*, *Lepraria*, *Lithographa*, *Micarea*, *Ochrolechia*, *Porpidia*, *Rhizocarpon*, and *Usnea*), which need

 Table 1.
 Collection sites. The locality IDs are identical those showing in Fig. 1. The detailed collection information of voucher specimens are shown in Supplement 1.

Locality ID	Locality (in Nagano Pref., Japan)	Elevation (m)	Collection date (d/m/y)	Note
1	Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Chino-city (N36°03', E138°19').	1807–1850	24/3/2018	Planted <i>Larix kaempferi</i> domi- nated forest with scattered broadleaf deciduous trees.
2	Near Hinatakoba observatory, Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Chino-city (N36°03', E138°19').	1936–1977	23-24/3/2018	Planted <i>Larix kaempferi</i> domi- nated forest with scattered <i>Abies</i> and broadleaf deciduous trees.
3	Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Chino-city (N36°03', E138°20').	2058	24/3/2018	Planted <i>Larix kaempferi</i> domi- nated forest with scattered broadleaf deciduous trees.
4	Kokemomononiwa, Mugikusa Pass, Kita- Yatsugatake, Yatsugatake Mts, Chino-city (N36°03', E138°20').	2065–2103	5/9/2014, 24/7/2015, 8/8/2015, 23–29/8/2016, 25/11/2016, 23–25/3/2017, 10–18/8/2017	Exposed rocky place sur- rounded by coniferous trees such as <i>Abies</i> , <i>Picea</i> , <i>Pinus</i> , <i>Tsuga</i> with scattered broadleaf deciduous tree such as <i>Betula</i> , <i>Sorbus</i> .
5	Komadorinoike, Mugikusa Pass, Kita- Yatsugatake, Yatsugatake Mts, Chino-city (N36°03', E138°21').	2116	12/8/2017	<i>Abies</i> dominated forest with a small pond.
6	Jigoku Valley, Mugikusa Pass, Kita-Yatsu- gatake, Yatsugatake Mts, Sakuho-town (N36°04', E138°21').	2128	25/8/2016, 23/11/2016, 23/8/2017	An old crater less than 100 m in diameter and c. 30 m depth. The area can become a pond with water depending on year.
7	Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Sakuho-town (N36°04', E138°21').	2100-2128	5/9/2014, 23/7/2015, 25/8/2016, 24/3/2017, 23/8/2017	<i>Abies</i> dominated forest with scattered other coniferous and broadleaf deciduous trees.
8	Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Chino-city (N36°04', E138°21').	2100–2128	2/7/2011, 26/3/2017, 25/3/2018	Abies dominated forest with scattered broadleaf deciduous trees at roadside near Mugi- kusa Hut
9	Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Chino-city (N36°03', E138°21').	2179–2210	4–8/9/2017, 25/3/2018	<i>Abies</i> dominated forest with scattered other coniferous and broadleaf deciduous trees.
10	Mt. Maruyama, Kita-Yatsugatake, Yatsugatake Mts, Sakuho-town (N36°03', E138°21').	2179–2300	15/6/2011, 27/8/2016, 16–21/8/2017, 5–9/9/2017, 25/3/2018	<i>Abies</i> dominated forest with scattered other coniferous and broadleaf deciduous trees and exposed rocky places.
11	Takamiishi, Kita-Yatsugatake Mts, Mina- misaku-gun (N36°03', E138°21').	2200-2250	15/6/2011	Exposed rocky place with coniferous surrounded by coniferous trees.
12	Around Shirakoma Pond, Mugikusa Pass, Kita-Yatsugatake, Yatsugatake Mts, Sakuho-town (N36°03', E138°22').	2050–2150	14–15/6/2011, 2/7/2011, 6/9/2014 24/12/2016	Abies dominated conifer forest with scattered broadleaf decid- uous trees around Shirakoma Pond.
13	Shirakoma Marsh, around Shirakoma Pond, Kita-Yatsugatake Mts, Minamisaku-gun (N36°03', E138°22').	c. 2150	15/6/2011	A marsh surrounded by <i>Abies</i> dominated forest.

further taxonomic studies to elucidate species identities. Among them, *Menegazzia caviisidia* Bjerke & P.James and *Usnea longissima* Ach. are known as the species of "Near Threatened (NT)" in the Red List 2020 of Ministry of the Environment, Government of Japan (Ministry of the Environment, Japan, 2020); *Baeomyces carneus* Flörke and *Cetrelia cetrarioides* (Delise) W.L.Culb. & C.F.Culb. were insufficiently understood in Japan; and *Peltigera neopolydactyla* (Gyeln.) Gyeln., and *Rhizocarpon hochstetteri* (Körb.) Vain. are needed further taxonomic revision worldwide. These species are discussed in detail on the following list.

The 141 ITS rDNA sequences were successfully obtained from 84 species. Eight taxa were new to GenBank: Alectoria lata, Cladonia crispata var. cetrariiformis, Lepra variolina, Menegazzia caviisidia, Pilophorus curtulus, Sphaerophorus meiophorus, Stereocaulon octomerum, and Viridothelium cinereoglaucescens; and two additional species, Asahinea scholanderi and Cladonia pseudoëvansii, are previously represented in GenBank but not with ITS rDNA sequences (accessed to the GenBank website on 13 Nov. 2022).

A species list of lichen collections

The species list is arranged alphabetically. Locality IDs are indicated in bold (see Table 1, Fig. 1). The specimen numbers indicate the collector names' abbreviation (MSu = Miyu Sugimoto, YO = Yoshihito Ohmura) and their serial number. In the parenthesis, substrate, elevation, collection date, and GenBank accession number (if available) are indicated.

1. Alectoria lata (Taylor) Linds

Specimens examined. **4:** MSu85 (on branch of *Pinus parviflora*, 2068 m elev., 24 Aug. 2016, LC742574), MSu195 (on trunk of weathered *Pinus parviflora*, 2071 m elev., 23 Mar. 2017). **7:** YO10707 (on trunk of *Picea jezoensis* var. *hon-doensis*, c. 2100 m elev., 23 July 2015, LC742575). **10:** MSu329 (on trunk of fallen tree, 2187 m elev., 20 Aug. 2017), MSu332 (on twig of *Tsuga diversifolia*, 2187 m elev., 20 Aug. 2017), MSu499 (on branch of *Pinus parviflora*, 2179 m elev., 25 Mar. 2018). **13:** YO8237 (on trunk of *Abies veitchii*, c. 2150 m elev., 15 June 2011).

2. Alectoria ochroleuca (Hoffm.) A.Massal.

Specimens examined. **4:** MSu204 (on humus over rock, 2088 m elev., 23 Mar. 2017), YO10725 (on rock, c. 2100 m elev., 24 July

2015, LC742576). **10:** MSu300 (on humus over exposed rock, 2188 m elev., 17 Aug. 2017, LC742577), MSu345 (on exposed rock, 2204 m elev., 21 Aug. 2017, LC742578), MSu346 (on exposed rock, 2204 m elev., 21 Aug. 2017, LC742579). **11:** YO8225 (on rock, c. 2250 m elev., 15 June 2011, LC742580), YO8226 (on rock, c. 2250 m elev., 15 June 2011, LC742581).

3. Anzia opuntiella Müll.Arg.

Specimens examined. 7: YO10704 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015). **10**: MSu125 (on mosses over trunk of *Abies mariesii*, 2276 m elev., 27 Aug. 2016), MSu321 (on trunk of coniferous tree, 2204 m elev., 20 Aug. 2017). **12**: YO8202 (on bark of *Tsuga diversifolia*, c. 2100 m elev., 14 June 2011), YO8236 (on bark of *Tsuga diversifolia*, c. 2150 m elev., 15 June 2011).

4. Arctoparmelia incurva (Pers.) Hale

Specimens examined. **4:** MSu187 (on exposed rock, 2090 m elev., 25 Dec. 2016, LC742582), YO10722 (on exposed rock, c. 2100 m elev., 24 July 2015). **10:** MSu287 (on exposed rock, 2181 m elev., 16 Aug. 2017, LC742583). **11:** YO8228 (on rock, c. 2250 m elev., 15 June 2011, LC742584).

5. Arctoparmelia separata (Th.Fr.) Hale

Specimens examined. **4:** MSu134 (on exposed rock, 2074 m elev., 29 Aug. 2016, LC742585), YO10728 (on exposed rock, c. 2100 m elev., 24 July 2015, LC742586).

6. Arthrorhaphis bullata Frisch & Y.Ohmura

Specimens examined. **4:** MSu220 (on mosses over rock, 2091 m elev., 25 Mar. 2017), YO10730 (on rock, c. 2100 m elev., 24 July 2015), YO10731 (on rock, c. 2100 m elev., 24 July 2015), YO10745 (on rock, c. 2100 m elev., 8 Aug. 2015), YO10976 (on mosses on rock, c. 2100 m elev., 5 Sept. 2014). **10:** MSu405 (on humus, 2225 m elev., 9 Sept. 2017). **11:** YO8230 (on mosses over rock, c. 2250 m elev., 15 June 2011).

7. *Arthrorhaphis farinosa* Frisch & Y.Ohmura Specimen examined. **10:** MSu288 (on humus over rock, 2181 m elev., 16 Aug. 2017).

8. *Asahinea chrysantha* (Tuck.) W.L.Culb. & C.F.Culb.



Fig. 2. Baeomyces carneus (MSu488, TNS). Scale = 1 mm.

Specimens examined. **4:** MSu122 (on exposed rock, 2090 m elev., 26 Aug. 2016, LC742587), YO10726 (on exposed rock, c. 2100 m elev., 24 July 2015, LC742588).

9. *Asahinea scholanderi* (Llano) W.L.Culb. & C.F.Culb.

Specimens examined. **4:** MSu185 (on rock, 2090 m elev., 25 Dec. 2016, LC742589), YO10738 (on rock, c. 2100 m elev., 24 July 2015, LC742590).

10. Baeomyces carneus Flörke

(Fig. 2)

Baeomyces carneus resembles *B. rufus* (Huds.) Rebent. in morphology that differs from the latter essentially in the production of norstictic acid rather than stictic acid (Thomson, 1967). This species was formerly reported from Yatsugatake Mts in Japan in Asahina [1958; as *B. rufus* var. *carneus* (Flörke) Nyl., Lich. Japon. Exs. 251], but it has been missed in checklists of Japanese lichens (Sato, 1959–1965; Kurokawa, 2003; Harada *et al.*, 2004; Kurokawa and Kashiwadani, 2006; Ohmura and Kashiwadani, 2018). The morphological and chemical features of the specimen collected from the study area agree well with the exsiccata of J. P. Norrlin: Herb. Lich. Fenn. 98 (TNS) and the description provided by Thomson (1967). It should be noted that baeomycesic acid was also detected in addition to norstictic acid when apothecium was included for the TLC analysis (there was no baeomycesic acid when thallus only). Moreover, the BLAST result of ITS rDNA of our sample shows more than 99% identity with *B. carneus* from Norway (MK811898, MK812113) (Marthinsen *et al.*, 2019). From these results, the occurrence of *B. carneus* in Japan was confirmed since 1958.

Specimen examined. **2:** MSu488 (on rock, 1965 m elev., 24 Mar. 2018, LC742591).

Exsiccati examined. JAPAN. Honshu. Shinano Prov. (Nagano Pref.): Shibu-no-yu, Mt. Yatugadake, on rock, c. 1800m elev., 3 Aug. 1958, *S. Kurokawa 58262* [Y. Asahina: Lich. Japon. Exs. 251] (TNS). FINLAND. In Tavastia, Evo, supra terram arenosam, sterilem, Ioco apricot, 1873, *J. P. Norrlin s.n.* [J. P. Norrlin: Herb. Lich. Fenn.

98] (TNS).

Other specimens examined. JAPAN. Honshu. Hida Prov. (Gifu Pref.): Hida-guchi 6-gome, Mt. Ontake, 19 Aug. 1954, *Y. Asahina 54180, 54181* (TNS).

11. Baeomyces placophyllus Ach.

Specimens examined. **4:** MSu132 (on humus, 2091 m elev., 28 Aug. 2016, LC742592), YO10737 (on soil on rock, c. 2100 m elev., 24 July 2015, LC742593). **11:** YO8234 (on rock, c. 2200 m elev., 15 June 2011, LC742594). **12:** YO8244 (on soil, c. 2100 m elev., 2 July 2011, LC742595).

12. Biatora alaskana Printzen & Tønsberg

Specimens examined. 7: MSu112 (on humus over trunk of *Abies mariesii*, 2128 m elev., 25 Aug. 2016, LC742596), YO10700 (on mosses on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742597). **10:** MSu313 (on trunk of *Tsuga diversifolia*, 2198 m elev., 19 Aug. 2017). **12:** YO8211 (on mosses over the trunk of *Abies veitchii*, c. 2150 m elev., 15 June 2011, LC742598).

13. **Bryocaulon pseudosatoanum** (Asahina) Kärnefelt

Specimen examined. **13:** YO8239 (on trunk of *Abies veitchii*, c. 2150m elev., 15 June 2011, LC742599).

14. *Bryoria furcellata* (Fr.) Brodo & D.Hawksw.

Specimens examined. **2:** MSu445 (on trunk of *Larix kaempferi*, 1936m elev., 23 Mar. 2018), MSu449 (on trunk of *Larix kaempferi*, 1936m elev., 23 Mar. 2018, LC742600).

15. Bryoria lactinea (Nyl.) Brodo & D.Hawksw.

Specimens examined. **5:** MSu267 (on twig of *Abies mariesii*, 2116m elev., 12 Aug. 2017). **7:** MSu111 (on trunk of *Abies mariesii*, 2128m elev., 25 Aug. 2016, LC742601), MSu217 (on branch of weathered wood, 2114m elev., 24 Mar. 2017).

16. *Bryoria nitidula* (Th.Fr.) Brodo & D.Hawksw.

Specimen examined. **10:** MSu342 (on humus over exposed rock, 2204 m elev., 21 Aug. 2017).

17. *Bryoria trichodes* (Michx.) Brodo & D.Hawksw.

Specimens examined. **7:** YO10708 (on trunk of *Picea jezoensis* var. *hondoensis*, c. 2100 m elev., 23 July 2015, LC742602). **13:** YO8238 (on trunk of *Abies veitchii*, c. 2150 m elev., 15 June 2011).

18. Calicium abietinum Pers.

Specimen examined. **4:** MSu191 (on trunk of weathered *Pinus parviflora*, 2071m elev., 23 Mar. 2017).

19. Calicium trabinellum (Ach.) Ach.

Specimen examined. **2:** MSu447 (on trunk of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018).

20. Cetraria laevigata Rass.

Specimens examined. **4:** MSu98 (on humus, 2067 m elev., 24 Aug. 2016, LC742603), MSu255 (on humus, 2089 m elev., 11 Aug. 2017), MSu256 (on humus, 2089 m elev., 11 Aug. 2017), YO10736 (on humus among rocks, c. 2100 m elev., 24 July 2015, LC742604), YO10739 (on humus among rocks, c. 2100 m elev., 24 July 2015, LC742605). **10:** MSu285 (on humus, 2181 m elev., 16 Aug. 2017), MSu382 (on humus, 2225 m elev., 7 Sept. 2017).

21. *Cetrelia cetrarioides* (Delise) W.L.Culb. & C.F.Culb.

Cetrelia cetrarioides is very similar to *C. monachorum* (Zahlbr.) W.L.Culb. & C.F.Culb. but they can be readily distinguished by the chemistry (i.e., *C. cetrarioides* contains perlatolic acid while *C. monachorum* contains imbricaric acid [major] with perlatolic acid [minor]) and the amount of pseudocyphellae on the lower side of sterile lobes (numerous to sparse in *C. cetrarioides* and absent to sparse in *C. monachorum*) (Obermayer and Mayrhofer, 2007). Their taxonomic independencies were confirmed by a molecular phylogenetic analysis based on four concatenated loci (ITS, IGS, *MCM7*, and *RPB1*) (Mark *et al.*, 2019).

The ITS rDNA sequences of MSu270 and YO10664 obtained in this study are 100% identical with those of *C. cetrarioides* retrieved from GenBank (MK812008 and MK812062 respectively [Marthinsen *et al.*, 2019]).

Specimens examined. 4: MSu270 (on twig of coniferous tree, 2069 m elev., 13 Aug. 2017,

LC742606). 7: YO10664 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742607).

22. *Cetrelia chicitae* (W.L.Culb.) W.L.Culb. & C.F.Culb.

Specimens examined. 1: MSu479 (on trunk of *Abies mariesii*, 1850m elev., 24 Mar. 2018). 2: MSu452 (on trunk of *Abies mariesii*, 1977m elev., 23 Mar. 2018).

23. *Chaenotheca chrysocephala* (Turner ex Ach.) Th.Fr.

Specimen examined. **2:** MSu448 (on trunk of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018).

24. Cladonia amaurocraea (Flörke) Schaer.

Specimens examined. **4:** MSu273 (on humus, 2071 m elev., 13 Aug. 2017). **10:** MSu298 (on humus, 2188 m elev., 17 Aug. 2017), MSu383 (on humus, 2225 m elev., 7 Sept. 2017).

25. *Cladonia arbuscula* (Wallr.) Flot. subsp. *beringiana* Ahti

Specimens examined. **4:** MSu95 (on humus, 2067 m elev., 24 Aug. 2016, LC742608), MSu308 (on humus, 2103 m elev., 18 Aug. 2017), YO10732 (on rock, c. 2100 m elev., 24 July 2015, LC742609).

26. Cladonia cariosa (Ach.) Spreng.

Specimen examined. **4:** YO10747 (on soil along a road, c. 2100 m elev., 8 Aug. 2015, LC742610) [= Y. Ohmura: Lich. Minus Cogn. Exs. 531].

27. *Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng.

Specimens examined. **8:** YO8245 (on soil over rock, c. 2100 m elev., 2 July 2011). **11:** YO8229 (on soil over rock, c. 2250 m elev., 15 June 2011).

28. *Cladonia crispata* (Ach.) Flot. var. *crispata* Specimen examined. **6:** MSu354 (on humus with mosses, 2128 m elev., 23 Aug. 2017).

29. *Cladonia crispata* var. *cetrariiformis* (Delise) Vain.

Specimens examined. **4:** YO10742 (on humus among rocks, c. 2100 m elev., 24 July 2015, LC742611). **10:** MSu283 (on humus, 2181 m elev., 16 Aug. 2017), MSu396 (on humus, 2225 m elev., 7 Sept. 2017), MSu398 (on humus, 2225 m elev., 8 Sept. 2017).

30. Cladonia cyanipes (Sommerf.) Nyl.

Specimen examined. **12:** YO8247 (on stump, 2120 m elev., 2 July 2011).

31. Cladonia digitata (L.) Hoffm.

Specimens examined. **10:** MSu127 (on decayed wood, 2276 m elev., 27 Aug. 2016, LC742612). **12:** YO8216 (on stump, c. 2150 m elev., 15 June 2011).

32. Cladonia fenestralis Nuno

Specimens examined. **4:** MSu304 (on humus, 2070 m elev., 18 Aug. 2017). **10:** MSu403 (on humus with mosses, 2225 m elev., 9 Sept. 2017, LC742613).

33. Cladonia furcata (Huds.) Schrad.

Specimens examined. **2:** MSu489 (on humus with mosses, 1965 m elev., 24 Mar. 2018). **4:** YO10741 (on humus among rocks, c. 2100 m elev., 24 July 2015, LC742614).

 Cladonia gracilis (L.) Willd. subsp. turbinata (Ach.) Ahti

Specimens examined. 4: MSu306 (on humus, 2101 m elev., 18 Aug. 2017). 6: MSu106 (on humus over rock, 2128m elev., 25 Aug. 2016, LC742615), MSu355 (on humus, 2128 m elev., 23 Aug. 2017). 9: MSu402 (on humus, 2210 m elev., 8 Sept. 2017). 10: MSu330 (on humus with mosses, 2187 m elev., 20 Aug. 2017), YO8221 (on fallen tree, c. 2250m elev., 15 June 2011). 11: YO8232 (on decayed stump, c. 2200 m elev., 15 June 2011). 12: YO8197 (on decayed stump, c. 2100 m elev., 14 June 2011), YO8206 (on humus, c. 2050m elev., 14 June 2011), YO8207 (on decayed wood, c. 2050m elev., 14 June 2011), YO8214 (on stump, c. 2150m elev., 15 June 2011), YO8240 (on fallen tree, c. 2150m elev., 15 June 2011) [= Y. Ohmura: Lich. Minus Cogn. Exs. 430], YO8246 (on humus, 2120 m elev., 2 July 2011).

35. Cladonia granulans Vain.

Specimen examined. **4:** MSu131 (on humus, 2091 m elev., 28 Aug. 2016, LC742616).

36. Cladonia krempelhuberi (Vain.) Zahlbr.

Specimen examined. **4:** MSu307 (on humus, 2101 m elev., 18 Aug. 2017).

 Cladonia kurokawae Ahti & S.Stenroos Specimen examined. 4: MSu137 (on humus over asphalt, 2083 m elev., 29 Aug. 2016, LC742617).

38. Cladonia macilenta Hoffm.

Specimens examined. **4:** MSu261 (on fallen tree, 2090 m elev., 11 Aug. 2017). **12:** YO8249 (on stump, 2120 m elev., 2 July 2011), YO10978 (on stump, c. 2100 m elev., 6 Sept. 2014, LC742618).

39. Cladonia maxima (Asahina) Ahti

Specimens examined. **4:** MSu97 (on humus, 2067 m elev., 24 Aug. 2016, LC742619). **10:** MSu294 (on humus, 2190 m elev., 17 Aug. 2017), MSu380 (on humus with mosses, 2225 m elev., 7 Sept. 2017), MSu404 (on humus with mosses, 2225 m elev., 9 Sept. 2017).

40. Cladonia nipponica Asahina

Specimen examined. **4:** YO10735 (on soil among rocks, c. 2100 m elev., 24 July 2015, LC742620).

41. Cladonia pleurota (Flörke) Schaer.

Specimens examined. **4:** MSu269 (on humus, 2068 m elev., 13 Aug. 2017). **7:** YO10973 (on humus, c. 2100 m elev., 5 Sept. 2014, LC742621). **10:** MSu386 (on humus, 2225 m elev., 7 Sept. 2017).

42. Cladonia pseudoëvansii Asahina

Specimens examined. **4:** MSu84 (on humus, 2068 m elev., 24 Aug. 2016, LC742622), MSu272 (on humus, 2071 m elev., 13 Aug. 2017). **10:** MSu320 (on humus, 2179 m elev., 19 Aug. 2017).

43. Cladonia pyxidata (L.) Hoffm.

Specimen examined. **12:** MSu182 (on humus over rock, 2128 m elev., 24 Dec. 2016, LC742623).

44. *Cladonia rangiferina* (L.) Weber ex F.H.Wigg. subsp. *rangiferina*

Specimens examined. **4:** MSu96 (on humus, 2067m elev., 24 Aug. 2016), YO10740 (on humus, c. 2100m elev., 24 July 2015, LC742624). **10:** MSu284 (on humus, 2181m elev., 16 Aug. 2017), MSu381 (on humus with mosses, 2225m elev., 7 Sept. 2017), MSu400 (on humus, 2226m elev., 8 Sept. 2017), YO8220 (on fallen tree, c. 2250m elev., 15 June 2011).

45. Cladonia rei Schaer.

Specimens examined. 4: MSu262 (on humus over rock, 2063 m elev., 12 Aug. 2017). 12:

YO8205 (on humus, c. 2050 m elev., 14 June 2011, LC742625).

46. Cladonia squamosa (Scop.) Hoffm.

Specimens examined. **12:** YO8196 (on decayed stump, c. 2100 m elev., 14 June 2011), YO8198 (on humus, c. 2100 m elev., 14 June 2011), YO8213 (on fallen tree, c. 2150 m elev., 15 June 2011), YO8215 (on fallen tree, c. 2150 m elev., 15 June 2011), YO8248 (on humus over rock, 2120 m elev., 2 July 2011).

47. Cladonia stellaris (Opiz) Pouzar & Vězda

Specimens examined. **4:** MSu93 (on humus, 2074 m elev., 24 Aug. 2016), MSu136 (on humus, 2068 m elev., 29 Aug. 2016, LC742626). **10:** MSu286 (on humus, 2181 m elev., 16 Aug. 2017), MSu385 (on humus, 2225 m elev., 7 Sept. 2017), MSu389 (on humus, 2225 m elev., 7 Sept. 2017).

48. Cladonia straminea (Sommerf.) Flörke

Specimens examined. **12:** MSu181 (on mosses over rock, 2128 m elev., 24 Dec. 2016, LC742627).

49. Cladonia uncialis (L.) Weber ex F.H.Wigg.

Specimens examined. **4:** MSu94 (on humus, 2067m elev., 24 Aug. 2016, LC742628). **10:** MSu299 (on humus, 2188m elev., 17 Aug. 2017), MSu384 (on humus, 2225 m elev., 7 Sept. 2017).

50. *Cladonia yunnana* (Vain.) Abbayes ex J.C.Wei & Y.M.Jiang

Specimens examined. **6:** MSu353 (on mosses, 2128 m elev., 23 Aug. 2017). **7:** YO10974 (on humus, c. 2100 m elev., 5 Sept. 2014, LC742629).

51. Coccocarpia erythroxyli (Spreng.) Swinscow & Krog

Specimens examined. 1: MSu456 (on trunk of *Abies mariesii*, 1807 m elev., 24 Mar. 2018).

52. *Coccocarpia palmicola* (Spreng.) Arv. & D.J.Galloway

Specimens examined. 1: MSu483 (on trunk of *Abies mariesii*, 1850 m elev., 24 Mar. 2018).

53. *Dibaeis arcuata* (Stirt.) Kalb & Gierl

Specimens examined. **10:** MSu279 (on humus, 2181 m elev., 16 Aug. 2017), MSu391 (on humus, 2225 m elev., 7 Sept. 2017), MSu395 (on humus, 2225 m elev., 7 Sept. 2017). **12:** YO8243 (on soil, c. 2100 m elev., 2 July 2011).

54. Evernia esorediosa (Müll.Arg.) Du Rietz

Specimens examined. 2: MSu444 (on trunk of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018). 4: MSu193 (on trunk of weathered *Pinus parviflora*, 2071 m elev., 23 Mar. 2017), MSu197 (on branch of *Pinus parviflora*, 2071 m elev., 23 Mar. 2017), MSu206 (on trunk of weathered wood, 2089 m elev., 23 Mar. 2017). 7: YO10663 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742630). 10: MSu333 (on twig of *Tsuga diversifolia*, 2187 m elev., 20 Aug. 2017).

55. Flavoparmelia caperata (L.) Hale

Specimens examined. **4:** MSu208 (on trunk of *Sorbus commixta*, 2103 m elev., 23 Mar. 2017), MSu219 (on trunk of *Abies veitchii*, 2092 m elev., 25 Mar. 2017), MSu221 (on trunk of *Pinus parviflora*, 2101 m elev., 25 Mar. 2017).

56. Graphis alpestris (Zahlbr.) Staiger

Specimens examined. **12:** YO8209 (on bark of *Tsuga diversifolia*, c. 2150 m elev., 15 June 2011), YO8210B (on bark of broad-leaf deciduous tree, c. 2150 m elev., 15 June 2011).

57. *Graphis kousyuensis* (Horik. & M.Nakan.) Lücking

Specimens examined. **10:** MSu315 (on trunk of *Tsuga diversifolia*, 2179m elev., 19 Aug. 2017), MSu326 (on trunk of *Tsuga diversifolia*, 2187m elev., 20 Aug. 2017).

58. Graphis scripta (L.) Ach.

Specimens examined. 1: MSu481 (on trunk base of *Abies mariesii*, 1850m elev., 24 Mar. 2018), 7: MSu212 (on trunk of *Betula ermanii*, 2124m elev., 24 Mar. 2017). 9: MSu512 (on weathered wood, 2179m elev., 25 Mar. 2018).

59. Graphis tenella Ach.

Specimens examined. 7: YO10669 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015).

60. *Gyalolechia flavorubescens* (Huds.) Søchting, Frödén & Arup

Specimens examined. 1: MSu466 (on fallen branch, 1807 m elev., 24 Mar. 2018).

61. Heterodermia microphylla (Kurok.) Skorepa

Specimens examined. 1: MSu458 (on trunk of *Abies mariesii*, 1807 m elev., 24 Mar. 2018). 7: MSu214 (on trunk of *Abies veitchii*, 2124 m elev., 24 Mar. 2017, LC742631).

62. Hypogymnia hypotrypa (Nyl.) Rass.

Specimens examined. **4:** MSu130 (on branch of *Tsuga diversifolia*, 2089 m elev., 28 Aug. 2016). **5:** MSu266 (on trunk of *Abies mariesii*, 2116 m elev., 12 Aug. 2017). **10:** MSu334 (on trunk of *Pinus parviflora*, 2186 m elev., 20 Aug. 2017).

63. Hypogymnia nikkoënsis (Zahlbr.) Rass.

Specimens examined. 1: MSu475 (on branch of *Larix kaempferi*, 1840 m elev., 24 Mar. 2018).

64. *Hypogymnia pseudophysodes* (Asahina) Rass.

Specimens examined. **2:** MSu454 (on trunk of *Abies mariesii*, 1977 m elev., 23 Mar. 2018, LC742632). **4:** MSu205 (on branch of *Sorbus commixta*, 2089 m elev., 23 Mar. 2017), MSu254 (on twig of coniferous tree, 2099 m elev., 10 Aug. 2017), MSu305 (on trunk of *Sorbus commixta*, 2090 m elev., 18 Aug. 2017).

65. Hypogymnia vittata (Ach.) Parrique

Specimens examined. **4:** MSu101 (on trunk of *Tsuga diversifolia*, 2065 m elev., 24 Aug. 2016, LC742633). **10:** MSu331 (on mosses over trunk of *Tsuga diversifolia*, 2187 m elev., 20 Aug. 2017). **12:** YO8199 (on stump, c. 2100 m elev., 14 June 2011, LC742634).

66. *Hypotrachyna spumosa* (Asahina) Krog & Swinscow

Specimens examined. **4:** MSu225 (on trunk of *Tsuga diversifolia*, 2082 m elev., 25 Mar. 2017).

67. *Icmadophila ericetorum* (L.) Zahlbr.

Specimens examined. **10:** MSu128 (on decayed wood, 2276m elev., 27 Aug. 2016, LC742635). **11:** YO8233 (on decayed stump, c. 2200m elev., 15 June 2011). **12:** YO8208 (on decayed stump, c. 2150m elev., 15 June 2011).

68. Imshaugia aleurites (Ach.) S.L.F.Mey.

Specimens examined. **2:** MSu442 (on trunk of weathered wood, 1936m elev., 23 Mar. 2018), MSu486 (on trunk of weathered wood, 1950m elev., 24 Mar. 2018). **4:** MSu129 (on branch of *Tsuga diversifolia*, 2089 m elev., 28 Aug. 2016, LC742636), MSu192 (on trunk of weathered *Pinus parviflora*, 2071 m elev., 23 Mar. 2017). **10:** MSu314 (on trunk of *Tsuga diversifolia*, 2179 m elev., 19 Aug. 2017), MSu497 (on weathered coniferous tree, 2179 m elev., 25 Mar.

2018), MSu498 (on weathered coniferous tree, 2179 m elev., 25 Mar. 2018).

69. Lecanora cinereofusca H.Magn.

Specimens examined. 7: YO10701 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742637).

70. Lecanora decorata Vain.

Specimens examined. **10:** MSu344 (on exposed rock, 2204m elev., 21 Aug. 2017), MSu511 (on exposed rock, 2179m elev., 25 Mar. 2018).

71. Lecanora hemiphracta Hue

Specimens examined. 7: MSu213 (on trunk of weathered wood, 2124 m elev., 24 Mar. 2017).

72. Lecanora polytropa (Hoffm.) Rabenh.

Specimens examined. **4:** YO10717 (on exposed rock, c. 2100 m elev., 24 July 2015, LC742638).

73. Lecanora pulicaris (Pers.) Ach.

Specimens examined. **12:** YO8200 (on bark of *Abies veitchii*, c. 2100 m elev., 14 June 2011, LC742639).

74. Lecanora sibirica Müll.Arg.

Specimens examined. 1: MSu477 (on trunk of weathered wood, 1846 m elev., 24 Mar. 2018).

75. Lepra multipuncta (Turner) Hafellner

Specimens examined. 1: MSu478 (on trunk of *Abies mariesii*, 1850 m elev., 24 Mar. 2018).

76. Lepra variolina (Nyl.) Q.Ren

Specimens examined. **4:** MSu102 (on trunk of *Pinus parviflora*, 2065 m elev., 24 Aug. 2016, LC742640), MSu200 (on trunk of *Pinus parviflora*, 2076 m elev., 23 Mar. 2017).

77. Leptogium cyanescens (Rabenh.) Körb.

Specimens examined. 1: MSu480 (on trunk of *Abies mariesii*, 1850m elev., 24 Mar. 2018). 7: MSu360 (on trunk of *Abies mariesii*, 2127m elev., 23 Aug. 2017, LC742641).

78. *Lichenomphalia hudsoniana* (H.S.Jenn.) Redhead, Lutzoni, Moncalvo & Vilgalys

Specimens examined. 6: MSu358 (on mosses, 2128 m elev., 23 Aug. 2017).

79. Lobaria linita (Ach.) Rabenh.

Specimens examined. **4:** MSu83 (on mosses, 2066 m elev., 23 Aug. 2016, LC742642). **10:** MSu276 (on mosses, 2184 m elev., 16 Aug. 2017), MSu310 (on humus, 2213 m elev., 19 Aug. 2017, LC742643), MSu323 (on trunk of

Tsuga diversifolia, 2187 m elev., 20 Aug. 2017). **11:** YO8231 (on tree trunk, c. 2200 m elev., 15 June 2011, LC742644). **12:** YO8217 (on trunk of *Betula ermanii*, c. 2150 m elev., 15 June 2011).

80. Loxospora ochrophaea (Tuck.) R.C.Harris

Specimens examined. 7: MSu215 (on trunk of *Picea jezoensis* var. *hondoensis*, 2113 m elev., 24 Mar. 2017). **10:** MSu352 (on trunk of *Tsuga diversifolia*, 2198 m elev., 21 Aug. 2017). **11:** YO8235 (on bark of *Tsuga diversifolia*, c. 2200 m elev., 15 June 2011).

81. *Melanelia hepatizon* (Ach.) A.Thell

Specimens examined. **12:** MSu183 (on rock, 2128 m elev., 24 Dec. 2016, LC742645).

82. Melanelia stygia (L.) Essl.

Specimens examined. **4:** MSu274 (on exposed rock, 2071 m elev., 13 Aug. 2017), YO10743 (on rock, c. 2100 m elev., 24 July 2015, LC742646). **10:** MSu502 (on exposed rock, 2179 m elev., 25 Mar. 2018).

 Melanohalea olivacea (L.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch

Specimens examined. **4:** MSu222 (on trunk of *Betula ermanii*, 2100 m elev., 25 Mar. 2017).

84. *Menegazzia anteforata* Aptroot, M.J.Lai & Sparrius

Specimens examined. **4:** MSu100 (on trunk of *Tsuga diversifolia*, 2065 m elev., 24 Aug. 2016, LC742647). **7:** YO10975 (on bark of *Abies veitchii*, c. 2100 m elev., 5 Sept. 2014, LC742648).

85. Menegazzia caviisidia Bjerke & P.James

This species is widely distributed in central Japan and Taiwan, and grows on coniferous trees such as *Pinus* and *Tsuga* at elevations between 970 and 2120 m in Japan and 2260 and 2600 m in Taiwan (Moon *et al.*, 2006). It is known as the species of "Near Threatened (NT)" category in the Red List 2020 of Japan (Ministry of the Environment, Japan, 2020). The finding of this species from this study area provides further supportable data on the preferences of habitat and tree.

Specimens examined. **10:** MSu317 (on trunk of *Tsuga diversifolia*, 2179 m elev., 19 Aug. 2017). **12:** YO10977 (on bark of *Tsuga diversifo*-

lia, c. 2100 m elev., 6 Sept. 2014, LC742649).

86. Menegazzia terebrata (Hoffm.) A.Massal.

Specimens examined. 1: MSu457 (on trunk of *Abies mariesii*, 1807 m elev., 24 Mar. 2018). 2: MSu453 (on trunk of *Abies mariesii*, 1977 m elev., 23 Mar. 2018). 4: MSu103 (on trunk of *Abies mariesii*, 2067 m elev., 24 Aug. 2016, LC742650).

87. *Montanelia panniformis* (Nyl.) Divakar, A.Crespo, Wedin & Essl.

Specimens examined. **4:** YO10733 (on rock, c. 2100 m elev., 24 July 2015, LC742651). **10:** MSu289 (on exposed rock, 2181 m elev., 16 Aug. 2017), MSu503 (on exposed rock, 2179 m elev., 25 Mar. 2018).

88. Mycoblastus sanguinarius (L.) Norman

Specimens examined. 2: MSu443 (on trunk of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018). 4: MSu201 (on trunk of *Pinus parviflora*, 2076 m elev., 23 Mar. 2017). 7: MSu110 (on trunk of *Abies mariesii*, 2128 m elev., 25 Aug. 2016, LC742652). 10: MSu316 (on trunk of *Tsuga diversifolia*, 2179 m elev., 19 Aug. 2017).

Myelochroa irrugans (Nyl.) Elix & Hale Specimens examined. 1: MSu482 (on trunk of *Abies mariesii*, 1850 m elev., 24 Mar. 2018).

90. Nephroma arcticum (L.) Torss.

Specimens examined. **10:** MSu319 (on mosses, 2179 m elev., 19 Aug. 2017, LC742653).

91. Nephroma resupinatum (L.) Ach.

Specimens examined. 1: MSu462 (on trunk of weathered wood, 1807m elev., 24 Mar. 2018), MSu467 (on trunk of broadleaf deciduous tree, 1977m elev., 24 Mar. 2018).

92. Nephromopsis endocrocea Asahina

Specimens examined. 7: YO10703 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015).

93. Nephromopsis ornata (Müll.Arg.) Hue

Specimens examined. **4:** MSu104 (on trunk of *Abies mariesii*, 2067 m elev., 24 Aug. 2016). **7:** YO10705 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015).

94. *Nephromopsis pseudocomplicata* (Asahina) M.J.Lai

Specimens examined. 10: MSu318 (on trunk of *Tsuga diversifolia*, 2179 m elev., 19 Aug.

2017).

95. *Nipponoparmelia laevior* (Nyl.) K.H.Moon, Y.Ohmura & Kashiw. ex A.Crespo *et al.*

Specimens examined. 4: MSu223 (on trunk of *Sorbus commixta*, 2100 m elev., 25 Mar. 2017). 8: MSu227 (on trunk of *Abies mariesii*, 2113 m elev., 26 Mar. 2017). 10: MSu328 (on trunk of *Tsuga diversifolia*, 2187 m elev., 20 Aug. 2017). 12: YO8201 (on bark of *Tsuga diversifolia*, c. 2100 m elev., 14 June 2011).

96. Normandina pulchella (Borrer) Nyl.

Specimens examined. 1: MSu463 (on trunk of weathered wood, 1807 m elev., 24 Mar. 2018).

97. Pannaria conoplea (Ach.) Bory

Specimens examined. 1: MSu459 (on trunk of *Abies mariesii*, 1807 m elev., 24 Mar. 2018).

98. Parmelia fertilis Müll.Arg.

Specimens examined. **4:** MSu207 (on trunk of *Picea jezoensis* var. *hondoensis*, 2097 m elev., 23 Mar. 2017). **10:** MSu312 (on trunk of *Tsuga diversifolia*, 2198 m elev., 19 Aug. 2017). **12:** YO8203 (on bark of *Sorbus commixta*, c. 2100 m elev., 14 June 2011).

99. Parmelia marmorophylla Kurok.

Specimens examined. **4:** MSu226 (on trunk of *Tsuga diversifolia*, 2082 m elev., 25 Mar. 2017).

100. Parmelia omphalodes (L.) Ach.

Specimens examined. **4:** MSu259 (on weathered wood, 2089 m elev., 11 Aug. 2017). **10:** MSu302 (on exposed rock, 2188 m elev., 17 Aug. 2017), MSu343 (on humus over exposed rock, 2204 m elev., 21 Aug. 2017).

101. Parmelia praesquarrosa Kurok.

Specimens examined. 1: MSu472 (on trunk of *Larix kaempferi*, 1807 m elev., 24 Mar. 2018).

102. Parmelia squarrosa Hale

Specimens examined. **4:** MSu202 (on trunk of *Pinus parviflora*, 2076 m elev., 23 Mar. 2017). **12:** YO8204 (on bark of *Sorbus commixta*, c. 2100 m elev., 14 June 2011).

103. Parmeliopsis ambigua (Wulfen) Nyl.

Specimens examined. **10:** MSu500 (on branch of *Pinus parviflora*, 2179 m elev., 25 Mar. 2018)

104. Peltigera aphthosa (L.) Willd.

Specimens examined. **4:** MSu114 (on humus, 2090 m elev., 26 Aug. 2016, LC742654). **10:**

MSu277 (on mosses, 2184 m elev., 16 Aug. 2017, LC742655).

105. Peltigera neopolydactyla (Gyeln.) Gyeln.

This species had been known as P. dolichorhiza (Nyl.) Nyl. in Japan. However, according to Magain et al. (2017a, b), the phylogenetic linage of P. dolichorhiza was only found in South America where it was originally described. Based on our preliminary analysis of BLAST with ca. 100 ITS rDNA sequences of Peltigera from various localities in Japan, they were not identical or close to those of P. dolichorhiza from South America registered in GenBank (unpublished data). Therefore, P. dolichorhiza could be excluded from Japanese lichen mycota, as Magain et al. (2017a, b) considered Asian and Australasia taxon is different from P. dolichorhiza. Japanese taxon that formerly identified as P. dolichorhiza could be assigned to P. neopolydactvla but it was polyphyletic in the phylogenetic trees and needed further taxonomic study (Magain et al., 2017a, b). This study tentatively treated the specimens from the study area as P. neopolydactyla.

Specimens examined. **6:** MSu356 (on mosses, 2128 m elev., 23 Aug. 2017, LC742656), MSu357 (on mosses, 2128 m elev., 23 Aug. 2017, LC742657). **7:** YO10716 (on rock with mosses, c. 2100 m elev., 23 July 2015, LC742658). **10:** MSu322 (on mosses, 2204 m elev., 20 Aug. 2017, LC742659), MSu372 (on humus with mosses, 2225 m elev., 5 Sept. 2017, LC742660), MSu401 (on humus with mosses, 2226 m elev., 8 Sept. 2017, LC742661), YO8218 (on humus, c. 2250 m elev., 15 June 2011). **12:** YO8195 (on rock with mosses, c. 2100 m elev., 14 June 2011).

106. Peltigera polydactylon (Neck.) Hoffm.

Specimens examined. **9:** MSu371 (on humus with mosses, 2210 m elev., 4 Sept. 2017, LC742662). **10:** MSu309 (on humus, 2213 m elev., 19 Aug. 2017, LC742663).

107. Pertusaria subfallens Vain.

Specimens examined. **4:** MSu203 (on branch of *Tsuga diversifolia*, 2079 m elev., 23 Mar. 2017). **7:** YO10667 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015). **10:** MSu292 (on trunk of

Tsuga diversifolia, 2191 m elev., 17 Aug. 2017).

108. Pertusaria subobductans Nyl.

Specimens examined. **10:** MSu311 (on trunk of *Tsuga diversifolia*, 2198 m elev., 19 Aug. 2017). 109. *Phylliscum japonicum* Zahlbr.

Specimens examined. **4:** MSu184 (on exposed rock, 2090 m elev., 25 Dec. 2016), MSu271 (on exposed rock, 2071 m elev., 13 Aug. 2017). **10:** MSu290 (on exposed rock, 2181 m elev., 16 Aug. 2017).

110. Physconia grumosa Kashiw. & Poelt

Specimens examined. 1: MSu468 (on trunk of broadleaf deciduous tree, 1807 m elev., 24 Mar. 2018).

111. Pilophorus clavatus Th.Fr.

Specimens examined. **4:** MSu113 (on rock, 2088 m elev., 26 Aug. 2016, LC742664). **10:** YO8222 (on rock, c. 2300 m elev., 15 June 2011, LC742665).

112. Pilophorus curtulus Kurok. & Shibuichi

Specimens examined. **6:** MSu359 (on mosses, 2128 m elev., 23 Aug. 2017, LC742666). **10:** MSu374 (on exposed rock, 2225 m elev., 5 Sept. 2017, LC742667).

113. *Platismatia interrupta* W.L.Culb. & C.F.Culb.

Specimens examined. **4:** MSu99 (on trunk of *Tsuga diversifolia*, 2065 m elev., 24 Aug. 2016, LC742668). **7:** YO10665 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742669).

114. Ramalina conduplicans Vain.

Specimens examined. 1: MSu469 (on trunk of broadleaf deciduous tree, 1807 m elev., 24 Mar. 2018). 3: MSu493 (on branch of *Sorbus commixta*, 2058 m elev., 24 Mar. 2018).

115. Ramalina dilacerata (Hoffm.) Hoffm.

Specimens examined. 1: MSu470 (on branch of broadleaf deciduous tree, 1807 m elev., 24 Mar. 2018, LC742670). 3: MSu491 (on branch of *Sorbus commixta*, 2058 m elev., 24 Mar. 2018). 4: MSu211 (on trunk of *Sorbus commixta*, 2103 m elev., 23 Mar. 2017).

116. Ramalina sinensis Jatta

Specimens examined. 3: MSu492 (on branch of *Sorbus commixta*, 2058 m elev., 24 Mar.

2018). 4: MSu209 (on trunk of Sorbus commixta, 2103 m elev., 23 Mar. 2017).

117. Rhizocarpon geographicum (L.) DC.

Specimens examined. 4: MSu120 (on exposed rock, 2090m elev., 26 Aug. 2016, LC742671). 10: MSu505 (on exposed rock, 2179 m elev., 25 Mar. 2018).

118. Rhizocarpon cf. hochstetteri (Körb.) Vain.

Rhizocarpon hochstetteri is characterized the grey-brown to red-brown cracked- areolate thallus, epruinose black lecideine apothecia (up to 1.5 mm diam.), aeruginosa to blue-black pigmented epihymenium, hyaline hymenium, branched and anastomosing paraphysoids, dark brown hypothecium, 1-septate hyaline to brown (when mature) as cospores (20–28 \times 8.5–14 µm) with thick gelatinous epispore, and the presence of stictic acid or no substance detected by TLC (Inoue, 1997; Fryday, 2002).

The specimen collected from the present area is largely coincide well with the features of above-mentioned morphology and chemistry with no lichen substance. However, ascospore size were somewhat larger [(22-)24-32(-33)] $\times 13-18(-20)$ (n = 11)]µm especially on the width for matured brownish ascospores) than the known value $(20-28 \times 8.5-14 \,\mu\text{m})$. The size of this species seems to be variable, as it is smaller in New Zealand (Fryday, 2002). It is difficult to determine by the examination of only one specimen whether the larger ascospore size is variation within a species or feature for a separate species. Further specimens with DNA data should be needed for the taxonomic evaluation. Until then, this specimen was tentatively identified as Rhizocarpon cf. hochstetteri.

Specimen examined. 4: MSu275 (on exposed rock, 2071 m elev., 13 Aug. 2017).

119. Rhizocarpon lecanorinum Anders

Specimen examined. 10: MSu278 (on rock, 2181 m elev., 16 Aug. 2017).

120. Sphaerophorus meiophorus (Nyl.) Vain.

Specimens examined. 10: MSu124 (on mosses over trunk of Abies mariesii, 2276m elev., 27 Aug. 2016, LC742672), MSu324 (on mosses over trunk of Tsuga diversifolia, 2187 m elev., 20 Aug. 2017, LC742673), MSu397 (on humus, 2225 m elev., 7 Sept. 2017, LC742674), MSu501 (on branch of Pinus parviflora, 2179m elev., 25 Mar. 2018, LC742675).

Stereocaulon apocalypticum Nyl. ex Mid-121. dend.

Specimens examined. 4: MSu92 (on exposed rock, 2074m elev., 24 Aug. 2016), MSu116 (on exposed rock, 2089m elev., 26 Aug. 2016, LC742676), YO10720 (on exposed rock, c. 2100m elev., 24 July 2015, LC742677). 10: MSu281 (on humus over rock, 2181 m elev., 16 Aug. 2017, LC742678). 12: YO8242 (on rock, c. 2100 m elev., 2 July 2011, LC742679).

122. Stereocaulon curtatum Nyl.

Specimens examined. 7: YO10709 (on rock, c. 2100m elev., 23 July 2015, LC742680), YO10711 (on rock, c. 2100 m elev., 23 July 2015, LC742681).

123. Stereocaulon exutum Nyl.

Specimens examined. 1: MSu474 (on humus over rock, 1807 m elev., 24 Mar. 2018). 4: MSu263 (on humus over rock, 2080 m elev., 12 Aug. 2017), MSu264 (on humus over rock, 2090 m elev., 12 Aug. 2017). 6: MSu105 (on rock, 2128 m elev., 25 Aug. 2016, LC742682). 7: YO10712 (on rock, c. 2100 m elev., 23 July 2015, LC742683). 10: MSu347 (on exposed rock, 2204 m elev., 21 Aug. 2017), YO8223 (on rock, c. 2300 m elev., 15 June 2011). 12: YO8212 (on rock, c. 2150 m elev., 15 June 2011).

Stereocaulon intermedium (Savicz) H.Magn. 124.

Specimens examined. 4: MSu90 (on exposed rock, 2076 m elev., 24 Aug. 2016), MSu133 (on exposed rock, 2076 m elev., 29 Aug. 2016, LC742684). 10: MSu336 (on humus, 2198 m elev., 20 Aug. 2017, LC742685), MSu350 (on exposed rock, 2204m elev., 21 Aug. 2017), MSu351 (on exposed rock, 2204 m elev., 21 Aug. 2017), MSu373 (on humus, 2225 m elev., 5 Sept. 2017, LC742686), MSu376 (on rock, 2225 m elev., 7 Sept. 2017, LC742687), MSu390 (on humus, 2225 m elev., 7 Sept. 2017).

125. Stereocaulon octomerellum Müll.Arg.

Specimens examined. 7: YO10710 (on rock, c. 2100 m elev., 23 July 2015, LC742688), YO10713 (on rock, c. 2100 m elev., 23 July 2015, LC742689).

126. Stereocaulon octomerum Müll.Arg.

Specimens examined. **4:** MSu88 (on exposed rock, 2075 m elev., 24 Aug. 2016, LC742690), MSu117 (on exposed rock, 2089 m elev., 26 Aug. 2016, LC742691), MSu135 (on exposed rock, 2074 m elev., 29 Aug. 2016, LC742692), YO10719 (on exposed rock, c. 2100 m elev., 24 July 2015), YO10721 (on exposed rock, c. 2100 m elev., 24 July 2015), YO10723 (on exposed rock, c. 2100 m elev., 24 July 2015, LC742693). **10:** MSu348 (on rock, 2204 m elev., 21 Aug. 2017), MSu377 (on rock, 2225 m elev., 7 Sept. 2017), MSu394 (on rock, 2225 m elev., 7 Sept. 2017).

127. Stereocaulon paschale (L.) Hoffm.

Specimen examined. **4:** YO10734 (on rock, c. 2100 m elev., 24 July 2015, LC742694).

128. *Stereocaulon pendulum* Asahina ex M.Satô

Specimens examined. 7: YO10972 (on rock, c. 2100 m elev., 5 Sept. 2014, LC742695). 10: MSu349 (on rock, 2204 m elev., 21 Aug. 2017).

129. Stereocaulon prostratum Zahlbr.

Specimens examined. **10:** MSu338 (on exposed rock, 2198 m elev., 20 Aug. 2017), MSu399 (on rock, 2225 m elev., 8 Sept. 2017), MSu407 (on rock, 2225 m elev., 9 Sept. 2017).

130. Stereocaulon vesuvianum Pers.

Specimens examined. **4:** MSu87 (on exposed rock, 2075 m elev., 24 Aug. 2016, LC742696), MSu89 (on exposed rock, 2077 m elev., 24 Aug. 2016, LC742697), MSu91 (on exposed rock, 2074 m elev., 24 Aug. 2016), MSu118 (on exposed rock, 2089 m elev., 26 Aug. 2016, LC742698), MSu119 (on exposed rock, 2089 m elev., 26 Aug. 2016), MSu123 (on exposed rock, 2090 m elev., 26 Aug. 2016), YO10718 (on exposed rock, c. 2100 m elev., 24 July 2015, LC742699). **10:** MSu340 (on humus, 2198 m elev., 20 Aug. 2017), MSu378 (on rock, 2225 m elev., 7 Sept. 2017).

Sulcaria sulcata (Lév.) Bystrek ex Brodo & D.Hawksw.

Specimen examined. 12: YO8250 (on trunk of coniferous tree, c. 2100 m elev., 2 July 2011,

LC742700).

132. Thamnolia subuliformis (Ehrh.) W.L.Culb.

Specimens examined. **10:** MSu303 (on mosses, 2188 m elev., 17 Aug. 2017), MSu339 (on mosses, 2198 m elev., 20 Aug. 2017).

133. Thamnolia vermicularis (Sw.) Schaer.

Specimens examined. **4:** YO10729 (on rock with mosses, c. 2100 m elev., 24 July 2015, LC742701). **10:** MSu280 (on humus over rock, 2181 m elev., 16 Aug. 2017). **11:** YO8227 (on rock, c. 2250 m elev., 15 June 2011).

134. *Thelotrema lepadinum* (Ach.) Ach.

Specimens examined. 7: YO10706 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742702). 10: MSu126 (on trunk of *Abies mariesii*, 2276 m elev., 27 Aug. 2016), MSu327 (on trunk of *Tsuga diversifolia*, 2187 m elev., 20 Aug. 2017). 12: YO8210A (on bark of broad-leaf deciduous tree, c. 2150 m elev., 15 June 2011, LC742703).

135. Tuckermanopsis gilva (Asahina) M.J.Lai

Specimen examined. **2:** MSu450 (on trunk of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018).

136. Umbilicaria caroliniana Tuck.

Specimens examined. **4:** MSu86 (on exposed rock, 2075 m elev., 24 Aug. 2016, LC742704), YO10727 (on exposed rock, c. 2100 m elev., 24 July 2015, LC742705). **10:** MSu341 (on exposed rock, 2204 m elev., 21 Aug. 2017).

137. Umbilicaria proboscidea (L.) Schrad.

Specimen examined. **10:** MSu301 (on exposed rock, 2188 m elev., 17 Aug. 2017, LC742706).

138. Umbilicaria torrefacta (Lightf.) Schrad.

Specimen examined. **10:** MSu291 (on exposed rock, 2181 m elev., 16 Aug. 2017).

139. Usnea longissima Ach.

This species is widely distributed in boreal regions of the northern hemisphere and from Hokkaido to Shikoku in Japan (Ohmura, 2001). The heavy decline of population has been reported in Europe, especially in Scandinavia, and is thought to be caused by climate change and forestry (Esseen *et al.*, 1981; Olsen and Gauslaa, 1991). The population in this study area are still well preserved especially in *Larix kaempferi* forest at elevations between 1800 and

2000 m (locality IDs 1 and 2, see Fig. 1).

Specimens examined. 1: MSu473 (on trunk of *Larix kaempferi*, 1807 m elev., 24 Mar. 2018). 2: MSu451 (on branch of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018). 7: MSu107 (on trunk of *Abies mariesii*, 2128 m elev., 25 Aug. 2016, LC742707), MSu109 (on branch of *Abies mariesii*, 2128 m elev., 25 Aug. 2016), YO10661 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742708). 12: YO8251 (on trunk of coniferous tree, c. 2100 m elev., 2 July 2011).

140. Usnea pygmoidea (Asahina) Y.Ohmura

Two chemotypes have been known for this species: (1) salazinic and (2) stictic acid as the major substance (Ohmura, 2001). From this study area, only salazinic acid chemotype (\pm norstictic acid) was found.

Specimens examined. **4:** MSu199 (on branch of *Pinus parviflora*, 2076 m elev., 23 Mar. 2017). **5:** MSu265 (on twig of *Abies mariesii*, 2116 m elev., 12 Aug. 2017). **7:** MSu218 (on trunk of *Abies mariesii*, 2114 m elev., 24 Mar. 2017), YO10662 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742709), YO10666A (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742710), YO10702 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742710), YO10702 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742710).

141. Usnea subfloridana Stirt.

Specimens examined. 1: MSu464 (on trunk of *Larix kaempferi*, 1807 m elev., 24 Mar. 2018), MSu465 (on trunk of *Larix kaempferi*, 1977 m elev., 24 Mar. 2018).

142. Varicellaria velata (Turner) I.Schmitt & Lumbsch

Specimen examined. **4:** MSu186 (on exposed rock, 2090 m elev., 25 Dec. 2016, LC742712).

143. *Viridothelium cinereoglaucescens* (Vain.) Lücking, M.P.Nelsen & Aptroot

Specimen examined. 7: YO10668 (on bark of *Abies veitchii*, c. 2100 m elev., 23 July 2015, LC742713).

144. *Vulpicida juniperinus* (L.) J.-E.Mattsson & M.J.Lai

Specimens examined. 10: MSu282 (on trunk of *Pinus pumila*, 2181 m elev., 16 Aug. 2017),

MSu295 (on trunk of weathered *Pinus pumila*, 2188 m elev., 17 Aug. 2017), MSu388 (on twig of *Tsuga diversifolia*, 2225 m elev., 7 Sept. 2017).
145. *Vulpicida pinastri* (Scop.) J.-E.Mattsson & M.J.Lai

Specimens examined. 1: MSu471 (on trunk of broadleaf deciduous tree, 1807m elev., 24 Mar. 2018). 4: MSu115 (on branch of *Pinus pumila*, 2092m elev., 26 Aug. 2016, LC742714). 10: MSu335 (on twig of *Pinus parviflora*, 2186m elev., 20 Aug. 2017).

146. *Xylopsora friesii* (Ach.) Bendiksby & Timdal

Specimen examined. **2:** MSu446 (on trunk of *Larix kaempferi*, 1936 m elev., 23 Mar. 2018).

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