国立科博専報，53号, pp. 65–105, 2026年3月28日
Mem. Natl. Mus. Nat. Sci., No. 53, pp. 65–105, March 28, 2026

Lichen Diversity in the Imperial Palace Grounds, Tokyo, Japan, Based on the Third Biodiversity Survey

Yoshihito Ohmura[1]*, Kensuke Tadome[2], Kiyoshi Kubo[3] and Kento Miyazawa[4]

[1] Department of Botany, National Museum of Nature and Science,
4–1–1 Amakubo, Tsukuba, Ibaraki 305–0005, Japan
*E-mail: ohmura-y@kahaku.go.jp
[2] Scientific Information Course, Tokyo University of Agriculture,
1–1–1 Sakuragaoka, Setagaya, Tokyo 156–8502, Japan
[3] Lichenological Society of Japan, c/o Department of Botany, National Museum of Nature and Science,
4–1–1 Amakubo, Tsukuba, Ibaraki 305–0005, Japan
[4] Tottori Prefectural Museum, 2–124 Higashimachi, Tottori, Tottori, 680–0011, Japan

Abstract. An inventory of lichens in the Imperial Palace Grounds, Tokyo, Japan, conducted between 2021 and 2025, identified a total of 110 taxa of lichens and allied fungi, comprising 66 genera, 82 species, and 28 taxa identified only to the genus level. These included three lichenicolous fungal taxa (three genera) and one non-lichenized fungal taxon. When combined with previous surveys conducted in 1995–1996 and 2009–2013, the cumulative number of taxa recorded from the area reaches 145 taxa (77 genera, 94 species, one variety, and 51 taxa identified only at the genus level), including three lichenicolous fungal taxa (three genera) and two non-lichenized fungal taxa (one genus). Among the taxa found in this study, *Lecanora neobarkmaniana*, *L. pseudargentata*, *Leprocaulon adhaerens*, *L. nicholsiae*, *Psoroglaena humidosilvae*, *Squamulea loekoesiana*, *Trapelia pruinosa,* and *T. terrestris* are newly reported from Japan, and 35 taxa are documented as new records for the Imperial Palace Grounds. These findings are based on both newly collected and previously collected specimens whose identities have now been clarified. Thirty-five taxa previously recorded were not confirmed in the present survey, probably due to their rarity and vulnerability to subtle habitat or substrate changes rather than actual local extinction, although the underlying causes remain unclear. In contrast to the recovery observed in earlier surveys, a recent decline of some lichen populations during the latter part of the study period may be associated with increasing temperatures and reduced precipitation. A preliminary survey was also conducted in Kitanomaru Park, located adjacent to the northern part of the Imperial Palace Grounds, and 21 species were identified from the area. Among these, *Graphis deserpens*, *Pyrenula fetivica* and *Remototrachyna incognita* were not found within the Imperial Palace Grounds, despite the detailed survey conducted there. The absence of these three species suggests that the environmental conditions within the Imperial Palace Grounds may differ from those in the adjacent large urban green space.

Keywords: Ascomycota, BLAST, DNA barcoding, lichenized fungi, taxonomy, urban area.

Introduction

The Imperial Palace Grounds, located in central Tokyo (35°41′N, 139°45′E), represent one of the few large and relatively undisturbed habitats within the highly developed metropolitan area. The site preserves semi-natural forests, old stone walls (ca. 400 years ago), and long-standing trees under restricted public access. Because of this unique setting, the area provides a valuable opportunity to document lichen diversity and to monitor envi-

ronmental changes over time.

The first lichen survey of the Imperial Palace Grounds in 1995–1996 recorded 57 species, including only four macrolichens (Kashiwadani and Thor, 1997, 2000). The subsequent second survey conducted in 2009–2013 revealed a substantial increase to 98 taxa, indicating a remarkable recovery of lichen diversity associated with improved air quality in Tokyo following strengthened emission regulations (Ohmura *et al.*, 2012, 2014). This increase demonstrated the sensitivity of lichens as biological indicators and highlighted the value of continued monitoring in urban environments.

Despite these advances, many specimens remained identified only to genus level, and several taxa showed uncertain taxonomic placement. Recent developments in lichen taxonomy and the accumulation of DNA sequence data in GenBank suggest that earlier records may include overlooked diversity or unidentified taxa, emphasizing the need for reassessment based on both morphological and molecular evidence.

In this context, the present study reports the results of the third lichen inventory conducted between 2021 and 2025. We document newly recorded species for Japan and for the Imperial Palace Grounds, and we clarify the taxonomic placement of previously ambiguous taxa based on morphological and molecular evidence. This study provides the most comprehensive overview of the lichen diversity of the Imperial Palace Grounds to date and offers an updated baseline for future ecological and taxonomic research in urban environments.

Material and Methods

Collections

The field surveys were carried out between September 2021 and December 2025 as part of the Third Biodiversity Survey of the Imperial Palace Grounds, conducted within the Integrated Research Project "A study of biota changes in urban environments over the past 150 years—Analysis of specimens collected mainly from the Imperial Palace in central Tokyo," initiated by the National Museum of Nature and Science, Japan. The collection sites are shown in Table 1 and Fig. 1. Lichens and allied fungi were collected from tree bark, rocks, soil, and man-made substrates such as stone walls and mortar. All voucher specimens are housed at the herbarium of the National Museum of Nature and Science (TNS), Tsukuba, Japan.

Morphology and chemistry

Morphological observations were made using a dissecting microscope (SZX16; Olympus, Tokyo, Japan) and a differential interference contrast microscope (BX51; Olympus) with a digital camera (EOS Kiss X10i; Canon, Tokyo, Japan). Anatomical observations were made using hand-cut sections mounted in water or GAW solution (glycerin : ethanol : water = 1:1:1; Asahina, 1936a).

Color spot tests for K, C, KC, and Pd were performed according to Orange *et al.* (2001). UV fluorescence of thallus and ascomata was tested at a wavelength of 365 nm. Amyloidity of fungal tissues was examined using Lugol's solution (I), either directly or after pretreatment with 5% KOH (K/I).

Lichen substances were examined using thin-layer chromatography (TLC) (Culberson and Kristinsson, 1970). Solvent B′ (hexane : methyl tert-butyl ether : formic acid, 140:72:18) (Culberson and Johnson, 1982) was used for TLC analysis. The TLC spot colors were checked under UV light at 254 nm and 365 nm and under visible light, before and after spraying the TLC plates with 10% sulfuric acid followed by charring at 110 °C for 10 minutes. When necessary, the microcrystal test (Asahina, 1936a–1940) was also performed.

DNA extraction, PCR, sequencing

Total DNA was extracted from small portions of thalli using a modified CTAB method based on Hosaka (2009) and Miyazawa *et al.* (2022). PCR amplification and sequencing of the fungal ITS rDNA (including partial 18S rDNA, ITS1, 5.8S rDNA, ITS2, and partial 28S rDNA) and mitochondrial small subunit (mtSSU) regions were performed following Ohmura *et al.* (2022) and Miyazawa *et al.* (2022), respectively. The primer sets used were ITS1F (Gardes and Bruns, 1993) and

Table 1. List of localities. All localities: Japan, Honshu, Musashi Prov. (Tokyo Metropolis), Chiyoda-ku, Imperial Palace Grounds, 35°41´N, 139°45´E. The locations of each sampling site are shown in Fig. 1.

Locality number (see Fig. 1)	Abbreviation	Locality	Collection date (d/m/y)	Note
1	Agency	Imperial Household Agency, ca. 15 m elev.	10/12/2021 10/3/2022 20/3/2022 17/1/2023	Old concrete walls and planted trees around the building of the Imperial Household Agency.
2	Bairinzaka-HG	Bairinzaka, Higashi-gyoen, 18 m elev.	27/2/2024	East-facing old stone wall.
3	Chikurin	Chikurin, 20 m elev.	13/4/2022	Old-growth deciduous forest.
4	Dokan-Shin	Dokan-bori-shinmichi, ca. 10 m elev.	10/12/2021 12/6/2025	A path crossing the moat.
5	Fujimi-HG	Fujimi-yagura, Higashi-gyoen, 7 m elev.	7/2/2023	An exposed old stone wall.
6	Fukiage	Fukiage-gyoen, 13 m elev.	10/12/2021	Old-growth deciduous forest with paths.
7	Hakucho	Hakucho-bori Pond, 15 m elev.	10/3/2022 6/12/2022	A small pond surrounded by deciduous trees.
8	Hanzo	Around Hanzo-bori Moat, 20–35 m elev.	13/4/2022 7/2/2023 27/2/2024	An exposed old stone wall.
9	Hisago	Hisago-ike Pond, 19 m elev.	7/2/2023	An open place with deciduous trees.
10	Honmaru	Honmaru, Higashi-gyoen, 20 m elev.	27/2/2024	Open place with scattered deciduous trees.
11	Inui	Inui avenue, 10 m elev.	29/9/2021 10/3/2022 16/12/2024 30/4/2025	Avenue with *Cerasus* × *yedoensis*, scattered *Acer* spp. and various trees.
12	Kain-tei	Kain-tei, Fukiage-gyoen, 25 m elev.	10/3/2022	An old house with a small pond in the garden.
13	Kamidokan	Around Kamidokan-bori Moat, 15–20 m elev.	20/5/2022	West-facing old stone wall surrounded by open forest along narrow road (40 m elev.); and mixed humid forest with scattered *Cryptomeria japonica* trees (20 m elev.).
14	Kanbaku	Kanbaku-tei, Fukiage-gyoen, 15 m elev.	10/12/2021 6/12/2022	Old-growth deciduous forest with scattered rocks near a small stream.
15	Kanko	Kanko-tei, Fukiage-gyoen, 25 m elev.	10/3/2022	Around a small house on a low hill with *Pinus thunbergii*.
16	Kashiko	Kashiko-dokoro, 20 m elev.	27/6/2023	Old *Prunus* spp. and *Cinnamomum camphora*.
17	Kikyo	Kikyo-mon Gate, 6 m elev.	7/2/2023	Open place with scattered broadleaf evergreen trees and pine trees.
18	Kitanomaru	Kitanomaru Park, ca. 25 m elev.	6/6/2023	Dominated by broadleaf forests with both evergreen and deciduous trees with lawn areas and small wetland sections along moats.
19	Kyuden	Kyuden-Nantei (Imperial Palace south garden), ca. 25 m elev.	17/1/2023	Exposed rocks along small stream in Japanese garden; and pebbles on the grounds of small hut.
20	Momijiyama	Momijiyama, 26 m elev.	17/1/2023	Broadleaf tree forest with exposed rocks.
21	Nakadokan	Kitazutsumi, Nakadokan-bori Moat, 25 m elev.	20/5/2022	Old stone wall.
22	Nishihane	Nishihanebashi Bridge, 19 m elev.	27/2/2024	Old stone wall along a moat.
23	Ohmichi	Ohmichi Garden, 20 m elev.	6/12/2022 27/6/2023	Nursery with bonsai trees, scattered other trees and greenhouses.
24	Ohmiya	Ohmiya-gosyo, Fukiage-gyoen, 25 m elev.	10/3/2022	Stone wall in an open area.
25	Oike	Around Oike Pond, 25 m elev.	10/12/2021	Around a pond surrounded by broadleaf deciduous trees.
26	Sakashita	Sakashita-mon Gate, Imperial Palace, 10 m elev.	17/1/2023	Near the gate (stone wall) and behind the building.
27	Sakurada	Around Sakurada-bori Moat, 15 m elev.	Not collected in 2021–2025	Old-growth forest along a road. Collected in 2013.
28	Sankaku	Stone wall near Sankaku-mon-ato, 10 m elev.	13/4/2022 7/2/2023	Shaded old stone wall.
29	Shimodokan	Shimodokan-bori Pond, 10 m elev.	10/3/2022	North-west facing old stone wall beside moat pond.
30	Shoko-mon	Shoko-mon Gate, 10 m elev.	17/1/2023	An open space near the gate.
31	Tomodamari	Tomodamari, 8 m elev.	7/2/2023	An open space along a road.
32	Yamazato	Yamazato-mon Gate, 25 m elev.	17/1/2023	An old stone wall surrounded by broadleaf trees.

Fig. 1. Collection sites in the Imperial Palace Grounds. Locality numbers and abbreviations of locality names are identical with those in Table 1. 1: Agency, 2: Bairinzaka-HG, 3: Chikurin, 4: Dokan-Shin, 5: Fujimi-HG, 6: Fukiage, 7: Hakucho, 8: Hanzo, 9: Hisago, 10: Honmaru, 11: Inui, 12: Kain-tei, 13: Kamidokan, 14: Kanbaku, 15: Kanko, 16: Kashiko, 17: Kikyo, 18: Kitanomaru, 19: Kyuden, 20: Momijiyama, 21: Nakadokan, 22: Nishihane, 23: Ohmichi, 24: Ohmiya, 25: Oike, 26: Sakashita, 27: Sakurada, 28: Sankaku, 29: Shimodokan, 30: Shoko-mon, 31: Tomodamari, 32: Yamazato.

LR1 (Vilgalys and Hester, 1990) for ITS rDNA, and mrSSU1 and mrSSU3R (Zoller *et al.*, 1999) for mtSSU. The newly obtained sequences were registered into GenBank. The accession numbers are shown in Table 2.

Sequences were compared with reference data in GenBank, and taxonomic decisions were made based on both morphological, chemical, and molecular data when applicable.

The obtained sequences were analyzed using the GenBank BLAST search (blastn) (https://blast.ncbi.nlm.nih.gov/, accessed 27 November 2025), with the default blastn settings. Newly obtained sequences were then aligned with selected taxa using MAFFT ver. 7 (Katoh *et al.*, 2019) with the default settings. In addition to the BLAST search, a preliminary phylogenetic analysis was conducted using the neighbor-joining (NJ) method (Saitou and Nei, 1987) in MEGA 11.0.13 (Tamura *et al.*, 2021). The resulting NJ trees were compared with available reference sequences and used as additional support for identification.

Table 2. Lichens and related fungi in the Imperial Palace Grounds in 1995–1996, 2009–2013, and 2021–2025. The GenBank accession numbers for the sequences obtained in this study are shown. IPG: Imperial Palace Grounds. KP: Kitanomaru Park. The following symbols preceding the taxon name denote: +, new to Japan; *, new to the Imperial Palace Grounds; †, previously recorded under different names or as unidentified; §, lichenicolous fungi or non-lichenized fungi.

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
1	*Agonimia opuntiella*	–	+	+	–		
2	*Agonimia pacifica*	+	+	+	–		
3	*Agonimia* sp.	–	–	+	–	LC918565 (YO14357)	
4	*Amandinea punctata*	+	+	+	–		"*Amandinea* sp." in Kashiwadani and Thor (2000)
5	*Arthonia pertabescens*	–	+	+	–		
6	§† *Arthonia phaeophysciae*	–	+	+	–		"*Arthonia* sp. #2" in Ohmura *et al*. (2014) Lichenicolous fungus
7	*Aspicilia cinerea*	–	+	+	–		
8	*Aspicilia* sp.	–	–	+	–	LC918566 (YO14381)	
9	*Bacidia* sp. 1	+	–	–	–		
10	*Bacidia* sp. 2	+	–	–	–		
11	*Bacidia* sp. 3	–	+	–	–		
12	*Bacidina apiahica*	–	–	+	–		Foliicolous lichen
13	*Bacidina* sp. 1	+	+	+	–	LC918567 (MS1024) LC918568 (MS1090) LC918569 (MS1104) LC918570 (MS1106) LC918571 (MS1107) LC918572 (YO13998) LC918573 (YO14025) LC918574 (YO14032) LC918575 (YO14242) LC918576 (YO14243) LC918577 (YO14245)	"Lichen sp. #2" in Kashiwadani and Thor (2000); including "*Bacidina* sp. 3" in Ohmura *et al*. (2014).
14	*Bacidina* sp. 2	–	+	–	–		
15	*Bacidina* sp. 3	–	–	+	–	LC918578 (YO9564) LC918579 (YO9565) LC918580 (YO9569) LC918581 (YO9570) LC918582 (YO9571) LC918583 (YO14232) LC918584 (YO14238) LC918585 (YO14256)	

Table 2. Continued

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
16	*Bacidina* sp. 4	–	–	+	–	LC918586 (YO14058)	
17	*Bacidina* sp. 5	–	–	+	–	LC918587 (MS1023)	
18	*Bacidina* sp. 6	+	+	+	–	LC918588 (GT29601)	"Lichen sp. 1" in Ohmura *et al*. (2014) and Kashiwadani and Thor (2000)
19	*Bilimbia* sp.	–	–	+	–	LC918589 for ITS, LC918645 for mtSSU (YO14046)	
20	*Botryolepraria lesdainii*	+	+	+	–		
21	*Buellia* cf. *mamillana*	–	–	+	–	LC918590 (YO14382)	
22	*Buellia* sp. 1	+	+	–	–		"*Buellia* sp." in Kashiwadani and Thor (2000)
23	*Buellia* sp. 2	–	+	–	–		
24	*Caloplaca* sp.	–	+	–	–		"*Caloplaca* sp. 2" in Ohmura *et al*. (2014)
25	*Candelaria asiatica*	–	+	+	+		"*Candelaria concolor*" in Kashiwadani and Thor (2000) and Ohmura *et al*. (2014)
26	†*Candelariella xanthostigmoides*	–	+	+	+		"*Candelariella* sp." in Ohmura *et al*. (2014)
27	*Canoparmelia aptata*	–	–	+	–		
28	*Chaenotheca hygrophila*	–	+	+	–		
29	*Chaenothecopsis nigra*	+	–	–	–		
30	*Chrysothrix* sp.	+	+	+	–		"*Chrysothrix flavovirens*" in Kashiwadani and Thor (2000)
31	*Cladonia caespiticia*	+	+	+	–		
32	*Cladonia kurokawae*	+	+	+	+		"*Cladonia humilis*" in Kashiwadani and Thor (2000)
33	*Cladonia rei*	–	+	+	–		"*Cladonia ramulosa*" in Ohmura *et al*. (2014)
34	*Coenogonium dilucidum*	+	–	–	–		"*Dimerella dilucida*" in Kashiwadani and Thor (2000)
35	*Coenogonium kawanae*	+	+	+	–		"*Dimerella kawanae*" in Kashiwadani and Thor (2000)
36	*Coenogonium pineti*	–	+	+	–		
37	*Collema subflaccidum*	–	–	+	–		
38	*Cresponea japonica*	–	+	+	–		
39	*Cresponea macrocarpoides*	–	–	+	–		

Table 2. Continued

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
40	*Dendrographa decolorans*	+	+	+	–		"*Opegrapha* sp. #2" in Kashiwadani and Thor (2000); "*Dendrographa* sp." in Ohmura *et al*. (2014); including "Lichen sp. 3" in Ohmura *et al*. (2014)
41	**Diploschistes muscorum*	–	–	+	–		
42	*Dirinaria applanata*	–	+	+	+		
43	*Endocarpon japonicum*	+	+	+	–		
44	*Endocarpon neopallidulum*	+	+	+	–		
45	**Endocarpon nigromarginatum*	–	–	+	–		
46	*Endocarpon petrolepideum*	–	+	+	–		
47	*Endocarpon superpositum*	+	+	+	–		
48	*Enterographa anguinella*	+	+	+	+		
49	*Enterographa hutchinsiae*	–	+	+	–		
50	*Fellhanera* sp. 1	+	+	–	–		"*Fellhanera* sp." in Kashiwadani and Thor (2000)
51	*Fellhanera* sp. 2	–	+	+	–		
52	*Flavoparmelia caperata*	–	+	+	+		
53	*Flavoplaca flavocitrina*	+	+	+	–		"*Caloplaca* aff. *citrina*" in Kashiwadani and Thor (2000) and Ohmura *et al*. (2014)
54	*Graphis deserpens*	–	–	–	+		
55	*Graphis handelii*	–	+	+	+		
56	**Graphis lineola*	–	–	+	–		
57	*Graphis scripta*	–	+	+	–		
58	**Heterodermia microphylla*	–	–	+	–		
59	*Hyperphyscia crocata*	–	+	+	+		
60	*Hypotrachyna minarum*	–	+	+	–		"*Parmelinopsis minarum*" in Ohmura *et al*. (2014)
61	**Hypotrachyna spumosa*	–	–	+	–		
62	*Inoderma nipponicum*	+	+	+	–		"Lichen sp. #3" in Kashiwadani and Thor (2000); "*Arthonia* sp. 1" in Ohmura *et al*. (2014); Frisch *et al*. (2015)
63	**Ionaspis lacustris*	–	–	+	–		
64	*Kashiwadia orientalis*	–	+	+	+		"*Physcia orientalis*" in Ohmura *et al*. (2014)
65	*Lecania erysibe*	+	+	+	–		
66	*Lecanora japonica*	+	–	–	–		
67	*Lecanora leprosa*	–	+	–	–		

Table 2. Continued

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
68	+*Lecanora neobarkmaniana*	+	+	+	–	LC918591 (MS1052) LC918592 (MS1100) LC918593 (YO7660) LC918594 (YO7665) LC918595 (YO7668) LC918596 (YO7671) LC918597 (YO7675) LC918598 (YO7678) LC918599 (YO7681) LC918600 (YO7691) LC918601 (YO7692) LC918602 (YO9584) LC918603 (YO14054) LC918604 (YO14057) LC918605 (YO14067) LC918606 (YO14068) LC918607 (YO14075)	"*Lecanora* sp. #1" in Kashiwadani and Thor (2000); "*Lecanora* sp." in Ohmura *et al.* (2014)
69	*Lecanora pseudargentata*	–	–	+	–	LC918608 (YO14492)	
70	*Lecanora pulverulenta*	+	+	+	+		
71	*Lecanora* sp.	–	–	+	–	LC918609 (MS965) LC918610 (YO14126)	
72	*Lecidea* sp. 1	+	+	–	–		"*Lecidea* sp." in Kashiwadani and Thor (2000)
73	*Lecidea* sp. 2	–	+	–	–		
74	*Lecidea* sp. 3 (*Lecidea* aff. *lapicida*)	–	+	–	–		
75	*Lecidea* sp. 4	–	–	+	–	LC918611 (YO13978) LC918612 (YO14044)	
76	*Lecidella elaeochroma* var. *caesitia*	–	+	–	–		
77	*Lecidella enteroleucella*	+	+	+	–		"*Lecidella* sp." in Kashiwadani and Thor (2000); "*Lecidella* sp. 1 (*Lecidella* sp.)" in Ohmura *et al*. (2014)
78	*Lecidella* sp.	–	+	+	–	LC918613 (YO8428) LC918614 (YO14372) LC918615 (YO14486)	This species differs from *Lecidella enteroleucella*.
79	*Lepraria cupressicola*	+	+	+	–		"*Lepraria* sp. #4" in Kashiwadani and Thor (2000)

Table 2. Continued

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
80	†*Lepraria finkii*	+	+	+	–	LC918616 (MS1049) LC918617 (YO6812) LC918618 (YO13983) LC918619 (YO14050) LC918620 (YO14064)	"*Lepraria lobificans*" in Kashiwadani and Thor (2000) and Ohmura *et al.* (2014)
81	*Lepraria vouauxii*	+	+	+	–		"*Leproloma vouauxii*" in Kashiwadani and Thor (2000)
82	*Lepraria* sp. 1	+	+	+	–	LC918621 (MS1050) LC918622 (YO14065) LC918623 (YO14236)	"*Lepraria* sp. #1" in Kashiwadani and Thor (2000)
83	†*Leprocaulon adhaerens*	–	–	+	–	LC918624 (YO13947)	
84	†*Leprocaulon nicholsiae*	+	+	+	+	LC918625 (MS1062) LC918626 (YO6834) LC918627 (YO6839) LC918628 (YO13999) LC918629 (YO14011) LC918630 (YO14031) LC918631 (YO14043) LC918632 (YO14305) LC918633 (YO14379)	"*Lepraria* sp. #2", "*Lepraria* sp. #3", and "*Lepraria* sp. #5" in Kashiwadani and Thor (2000); "*Lepraria* sp. 2" and "*Lepraria* sp. 3" in Ohmura *et al.* (2014)
85	*†*Leptogium azureum*	–	–	+	–		
86	§*†*Lichenochora* sp.	–	–	+	–		Lichenicolous fungus
87	§*Lichenothelia* sp. 1	+	–	–	–		Non-lichenized fungus
88	§*Lichenothelia* sp. 2	+	+	+	–		Non-lichenized fungus
89	*Lichinella japonica*	+	+	+	–		
90	*Lithothelium japonicum*	–	+	+	–		
91	*Micarea byssacea*	–	+	–	–		"*Micarea* sp." in Ohmura *et al.* (2014)
92	**Micarea* sp. 1	–	–	+	–		
93	**Myelochroa aurulenta*	–	–	+	+		
94	*Normandina pulchella*	–	+	–	–		
95	*Opegrapha* sp. 1	–	+	+	–		It is not the same as "*Opegrapha* sp. #1" in Kashiwadani and Thor (2000).
96	*Opegrapha* sp. 2	–	+	–	–		
97	*Opegrapha* sp. 3	+	+	+	–		"*Opegrapha* sp. #3" in Kashiwadani and Thor (2000)
98	*Opegrapha* sp. 4	–	+	–	–		

Table 2. Continued

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
99	*Parmotrema austrosinense*	–	+	+	+		
100	*Parmotrema clavuliferum*	–	+	+	+		
101	*Parmotrema tinctorum*	–	+	+	+		
102	*Pertusaria flavicans*	–	+	+	–		
103	*Pertusaria pertusa*	–	+	–	–		
104	**Pertusaria pustulata*	–	–	+	–		
105	*Pertusaria* sp.	–	+	–	–		
106	*Phaeographis pruinosa*	–	+	–	–		
107	*Phaeophyscia limbata*	–	+	+	+		"*Phaeophyscia hispidula*" in Ohmura *et al*. (2014)
108	*Phaeophyscia rubropulchra*	+	+	+	+		
109	**Phaeophyscia spinellosa*	–	–	+	–		
110	*Physciella melanchra*	+	+	+	–		
111	*Placynthiella icmalea*	+	+	+	–		
112	*Polyblastia* sp.	+	–	–	–		
113	*Porina hirsuta*	+	+	+	–		"*Porina* sp. #1" in Kashiwadani and Thor (2000)
114	*Porina leptalea*	+	+	+	–		"*Porina* sp. #2" in Kashiwadani and Thor (2000)
115	*Porina* sp. 1	–	+	–	–		It is not the same as "*Porina* sp. #1" in Kashiwadani and Thor (2000).
116	*Porina* sp. 2	–	+	–	–		It is not the same as "*Porina* sp. #2" in Kashiwadani and Thor (2000).
117	*Porina* sp. 3	+	+	+	–		"*Opegrapha* sp. #1" in Kashiwadani and Thor (2000)
118	**Porina* sp. 4	–	–	+	–		
119	*Porpidia albocaerulescens*	+	+	+	–		
120	*+Psoroglaena humidosilvae*	–	+	+	–	LC918634 (GT29654, on old asphalt, 8 March 2013) LC918635 (YO11246, an additional specimen from another locality of Tokyo)	"Lichen sp. 2" in Ohmura *et al*. (2014) This is not the same as "Lichen sp. #2" in Kashiwadani and Thor (2000).
121	*Punctelia borreri*	–	+	+	+		
122	**Punctelia ruderata*	–	–	+	–		
123	*Pyrenopsis* sp.	+	+	+	–		
124	*Pyrenula fetivica*	–	–	–	+		
125	*Pyrenula* sp.	–	+	–	–		

Table 2. Continued

	Species	1995–1996	2009–2013	2021–2025		GenBank no. (voucher specimen)	Notes
		IPG	IPG	IPG	KP		
126	*Pyxine sorediata*	–	–	+	–		
127	*Ramonia luteola*	+	+	–	–		
128	*Remototrachyna incognita*	–	–	–	+		
129	*Rinodina oxydata*	–	–	+	–		
130	†*Scoliciosporum chlorococcum*	–	+	+	–		The corticolous "*Scoliciosporum umbrinum*" reported in Ohmura *et al*. (2014) corresponds to this species.
131	*Scoliciosporum umbrinum*	+	–	–	–		
132	*Sculptolumina japonica*	–	+	–	–		
133	+*Squamulea loekoesiana*	+	+	+	–	LC918636 (MS986) LC918637 (MS1051) LC918638 (YO7674) LC918639 (YO14059) LC918640 (YO14241)	"*Caloplaca* sp. 1" in Ohmura *et al*. (2014)
134	*Stereocaulon* sp.	–	–	+	–		
135	*Strangospora* sp.	–	+	–	–		
136	*Strigula* sp.	–	+	–	–		
137	*Thelidium japonicum*	–	+	–	–		
138	*Thelidium rehmii*	–	–	+	–		
139	*Trapelia coarctata*	+	+	+	–		
140	*Trapelia placodioides*	+	+	+	–		
141	+*Trapelia pruinosa*	–	–	+	–	LC918641 (YO14326)	
142	+*Trapelia terrestris*	–	–	+	–	LC918642 (MS982) LC918643 (YO13970)	
143	*Trapelia* sp.	–	–	+	–		
144	§+*Trimmatostroma* sp.	–	–	+	–		Lichenicolous fungus
145	*Trimmatothelopsis* sp.	+	+	+	–	LC918644 (YO9598)	"*Acarospora* sp." in Kashiwadani and Thor (2000) and Ohmura *et al*. (2014)
146	*Verrucaria* sp. 1	+	+	+	–		Including "*Verrucaria* sp. 3" in Ohmura *et al*. (2014).
147	*Verrucaria* sp. 2	+	+	+	–		
148	*Verrucaria* sp. 4	–	+	–	–		

Results and Discussion

A total of 110 taxa of lichens and allied fungi were identified based on 514 specimens collected during 2021–2025, including 66 genera, 82 species, and 28 taxa identified only at the genus level. Among them, three lichenicolous fungal taxa (three genera) and one non-lichenized fungal taxon were included. When combined with previous surveys conducted in 1995–1996 and 2009–2013, the cumulative number of taxa identified from this area reaches 145 taxa (77 genera, 94 species, one variety, and 51 taxa identified only at the genus level), including three lichenicolous fungal taxa (three genera) and two non-lichenized fungal taxa (one genus) (Table 2).

Among the taxa found in this study, *Lecanora neobarkmaniana*, *L. pseudargentata*, *Leprocaulon adhaerens*, *L. nicholsiae*, *Psoroglaena humidosilvae*, *Squamulea loekoesiana*, *Trapelia pruinosa,* and *T. terrestris* are newly reported from Japan, and 35 taxa are documented as new records for the Imperial Palace Grounds. These findings are based on both newly collected and previously collected specimens whose identities have now been clarified.

Although a rich lichen diversity was confirmed within the Imperial Palace Grounds, 52 taxa were identified only to the genus level. While the taxonomic identities of several taxa previously recorded as "sp." or even as "Lichen sp." have been clarified in the present study, further taxonomic work is still required to resolve their species-level identities.

A preliminary survey was also conducted in Kitanomaru Park, located adjacent to the northern part of the Imperial Palace Grounds, and 21 species were identified from the area. Among these, *Graphis deserpens*, *Pyrenula fetivica* and *Remototrachyna incognita* were not found within the Imperial Palace Grounds, despite the detailed survey conducted there. The absence of these three species suggests that the environmental conditions within the Imperial Palace Grounds may differ from those in the adjacent large urban green space.

Species List

The list is arranged alphabetically. Numbers and/or letters following collector abbreviations indicate the collection numbers of AF (A. Frisch), GT (G. Thor), MS (M. Sugimoto) and YO (Y. Ohmura). The symbols preceding the scientific names in the species list indicate the following:

+: new to Japan

*: new to the Imperial Palace Grounds

†: previously recorded under different names or as unidentified

§: lichenicolous fungi or non-lichenized fungi.

Selected photographs are presented for these noteworthy species when available.

1. **Agonimia opuntiella*** (Buschardt & Poelt) Vězda

(Fig. 2A)

The occurrence was confirmed from past and present material.

Specimens examined. Kamidokan: YO7682 (on soil, 13 October 2010). Nakadokan: YO14136 (on mosses on stone wall, 20 May 2022).

2. ***Agonimia pacifica*** (H. Harada) Diederich

Specimens examined. Oike; YO13994 (on bark of *Aphananthe aspera*, 10 December 2021), YO14004 (on decayed stump, 10 December 2021).

3. **Agonimia*** sp.

(Fig. 2B)

This species is sterile and lacks distinctive morphological characteristics, making it difficult to distinguish from the thalli of other *Agonimia* species in this area. The ITS sequence differs from those of *A. opuntiella* and *A. pacifica*, suggesting that it represents a separate species. The BLAST result for the sequence of specimen YO14357 shows only 82.03% similarity to *Verrucaria csernaensis* Zschacke from the United Kingdom (FJ645260, unpublished), and no closely related sequences are currently present in the GenBank. Thus, its taxonomic identity remains uncertain based on the available

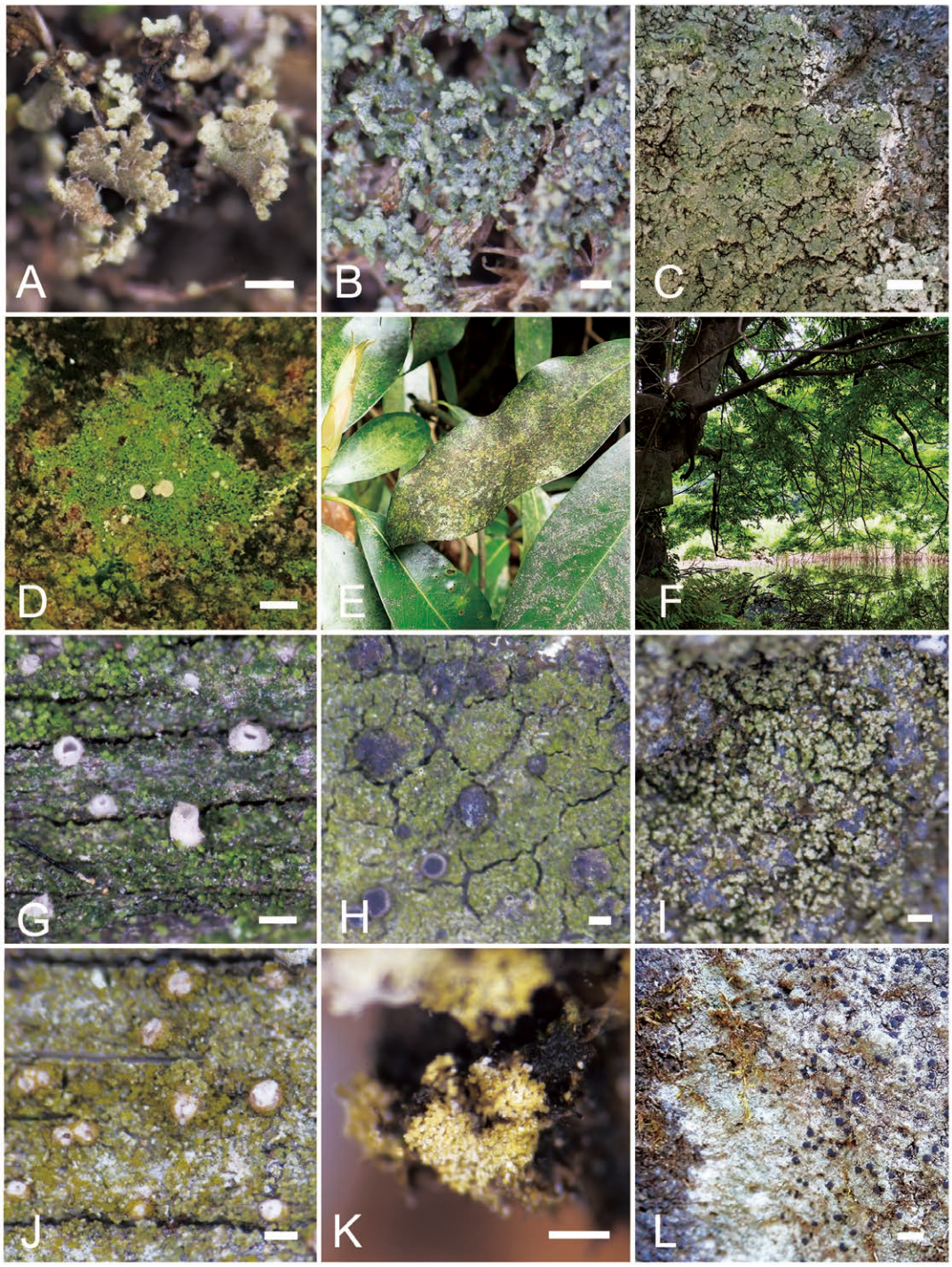

Fig. 2. Selected images of lichens from the Imperial Palace Grounds. A. *Agonimia opuntiella* (YO14136). B. *Agonimia* sp. (YO14357). C. *Aspicilia* sp. (YO14381). D. *Bacidina apiahica* (MS1067). E. *Bacidina apiahica* growing on leaf of *Machilus thunbergii*. F. Habitat of *Bacidina apiahica*. G. *Bacidina* sp. 1 (YO14032). H. *Bacidina* sp. 3 (YO14232). I. *Bacidina* sp. 4 (YO14058). J. *Bacidina* sp. 5 (MS1023). K. *Bacidina* sp. 6 (GT29541). L. *Bilimbia* sp. (YO14046). Scales: A, B, G–K = 200 μm, C, L = 2 mm, D = 0.5 mm.

DNA data.

Specimen examined. Ohmichi: YO14357 (on bark of *Cerasus* sp., 27 June 2023).

4. ***Amandinea punctata*** (Hoffm.) Coppins & Scheid.

Specimens examined. Agency: YO14009 (on bark of *Zelkova serrata*, 10 December 2021). Inui: MS963 (on bark of *Pinus thunbergii*, 29 September 2021), YO14501 (on bark of *Acer amoenum* 'Oosakazuki', 16 December 2024). Kanko: MS1032 (on bark of *Pinus thunbergii*, 10 March 2022). Kikyo: MS1133 (on trunk base of *Cinnamomum camphora*, 7 February 2023), YO14342 (on trunk base of *Pinus thunbergii*, 7 February 2023). Tomodamari: MS1125 (on bark of *Torreya nucifera*, 7 February 2023).

5. ***Arthonia pertabescens*** Nyl.

Specimens examined. Inui: YO13958, YO13959 (on bark of *Acer palmatum*; 29 September 2021), YO14494 (on bark of *Acer palmatum*, 16 December 2024).

6. §† ***Arthonia phaeophysciae*** Grube & Matzer

It was previously reported as "*Arthonia* sp. #2" in Ohmura *et al.* (2014), but it has now been identified as this species, a lichenicolous fungus growing on *Physciella melanchra* (Hue) Essl.

Specimen examined. Inui: YO13966 pr.p. (on *Physciella melanchra* on concrete, 29 September 2021).

7. ***Aspicilia cinerea*** (L.) Körb.

Specimens examined. Hanzo: YO14055, YO14070, YO14077 (on stone wall, 13 April 2022). Nishihane: YO14380 (on stone wall, 27 February 2024).

8. * ***Aspicilia*** sp.

The BLAST result for the sequence of specimen YO14381 shows only 87.58% similarity to *Sagedia zonata* Ach. [= *Aspicilia zonata* (Ach.) R. Sant.] from Poland (OP602293; Szczepańska *et al*., 2023), and no closely related sequences were found in GenBank; however, the specimen is clearly distinct from *A. cinerea*.

Specimen examined. Nishihane: YO14381 (on stone wall, 27 February 2024).

9. ***Bacidia*** sp. 1

For a detailed description, see Kashiwadani and Thor (2000). This species is distinguished from the related taxa in this area by the large (up to 0.7 mm in diam.), greyish brown apothecia and the 2–4-septate ascospores. It was only found once on an old, exposed stump in Ohmichi Garden in 1995–1996 (Kashiwadani and Thor, 2000). The substrate is thought to have already been removed.

Not confirmed during 2021–2025 survey.

10. ***Bacidia*** sp. 2

For a detailed description, see Kashiwadani and Thor (2000). This species is distinguished from the related taxa in this area by the K+ brownish red to violet red hypothecium and the broad, (1-)3(-5)-septate ascospores. It was found on rocks in semi-shaded and humid habitats at three localities in 1995–1996 (Kashiwadani and Thor, 2000).

Not confirmed during 2021–2025 survey.

11. ***Bacidia*** sp. 3

It belongs to "*Bacidia rubella* group", characterized by the large, pale to reddish apothecia and acicular ascospores (Ohmura *et al.*, 2014). It was only found once on *Cinnamomum camphora* in 2009–2013.

Not confirmed during 2021–2025 survey.

12. * ***Bacidina apiahica*** (Müll. Arg.) Vězda (Fig. 2D–F)

It is the only foliicolous lichen found in the Imperial Palace Grounds, growing in a moist, swampy environment.

Specimen examined. Kamidokan: MS1067 (on leaves of *Machilus thunbergii*, 20 May 2022).

13. ***Bacidina*** sp. 1 (Fig. 2G)

This species is characterized by a greenish thallus with white, hollow or elevated pycnidia. Although Ohmura *et al.* (2014) distinguished taxa (*Bacidina* sp. 1 and *Bacidina* sp. 3) based on whether the pycnidia

were hollow or elevated, these differences are regarded as intraspecific variation according to the ITS data.

The ITS sequences show 94.21–96.73% similarity to those of *Bacidina pycnidiata* (Czarnota & Coppins) Czarnota & Guz.-Krzem. (GenBank KX239033, KX239034, Czarnota and Guzow-Krzemińska, 2018). However, these specimens do not represent *B. pycnidiata* (Dr. G. Thor, pers. comm.).

Specimens examined. Hakucho: MS1024 (on rock, 10 March 2022), MS1090 (on rock, 6 December 2022), YO14025 (on rock, 10 March 2022), YO14032 (on wooden bridge, 10 March 2022). Inui: YO13980 (on wooden plate, 29 September 2021). Ohmichi: MS1104, MS1107 (on rock, 6 December 2022), MS1106 (on unglazed flowerpot, 6 December 2022), YO14242 (on wooden plate, 6 December 2022), YO14243 (on rock, 6 December 2022), YO14245 (on brick, 6 December 2022). Oike: YO13998 (on rock, 10 December 2021).

14. ***Bacidina*** sp. 2

This species is similar to *Bacidina chloroticula* (Nyl.) A.L. Sm. but differs in morphology of apothecia and conidia (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

15. ****Bacidina*** sp. 3

(Fig. 2H)

The *Bacidina* sp. 3 treated in this study is not the same taxon as "*Bacidina* sp. 3" reported by Ohmura *et al.* (2014). The ITS sequences show 94.55–96.73% similarity to those of *Bacidina egenula* (Nyl.) Vězda. (GenBank KY379233, PQ499467, Czarnota and Guzow-Krzemińska, 2018). However, these specimens do not correspond to *B. egenula* (Dr. G. Thor, pers. comm.).

Specimens examined. Hakucho: YO14232 (on wooden pole, 6 December 2022). Ohmichi: YO9564 (on soil, 6 March 2013), YO9565 (on rock in a shady and humid place, 6 March 2013), YO9569 (on tile in a shady and humid place, 6 March 2013), YO9570, YO9571 (on brick in a shady and humid place, 6 March 2013), YO14238 (on brick, 6 December 2022), YO14239 (on mortar, 6 December 2022), YO14256 (on fragment of roof tile, 6 December 2022).

16. ****Bacidina*** sp. 4

(Fig. 2I)

The thallus is sterile and granular-sorediate lacking apothecia. Because of this, species-level identification could not be performed, although the ITS sequence shows 96.61% similarity to those of *Bacidina friesiana* (Hepp) S. Ekman (GenBank ON352609; Lee and Hur, 2022).

Specimens examined. Hanzo: YO14058 (on stone wall, 13 April 2022).

17. ****Bacidina*** sp. 5

(Fig. 2J)

The ITS sequence shows 97.41% similarity to those of *Bacidina iqbalii* K. Habib & Khalid (GenBank MT952885, Fatima *et al*., 2020). Its taxonomic identity remains unresolved, and it is treated here as "*Bacidina* sp. 5".

Specimen examined. Hakucho: MS1023 (on wooden bridge, 10 March 2022).

18. ***Bacidina*** sp. 6

(Fig. 2K)

This species corresponds to "Lichen sp. 1" in Ohmura *et al.* (2014). As described in detail by Kashiwadani and Thor (2000), it is a sterile, yellowish, sorediate crustose lichen. The thallus morphology and the color closely resemble *Bacidina adastra* (Sparrius & Aptroot) M. Hauck & V. Wirth and *B. flavoleprosa* Czarnota & Guzow-Krzem. (Czarnota and Guzow-Krzemińska, 2012). Also, the ITS sequence of GT29601 (see Ohmura *et al.*, 2014) shows only moderate similarity to those of *B. adastra* (94.38%, OK332938; Vondrák *et al.*, 2022) and *B. flavoleprosa* (94.17%, JN972443; Czarnota and Guzow-Krzemińska, 2012), its taxonomic position remains uncertain and requires further study. Therefore, it is pro-

visionally treated here as *Bacidina* sp. 6.

Specimen examined. Inui: MS985 (on rock, 29 September 2021).

19. **Bilimbia* sp.

(Fig. 2L)

The BLAST result for the mtSSU sequence of specimen YO14046 shows 98.57% similarity to *Bilimbia fuscoviridis* Anzi from Czech Republic (GenBank PQ499452; Malíček 2024). As the taxonomic identity of the specimen cannot be clarified, it is treated here as "*Bilimbia* sp."

Specimens examined. Inui: YO14046 (on stone wall, 10 March 2022). Oike: YO14003 (on rock, 10 December 2021).

20. ***Botryolepraria lesdainii*** (Hue) Canals, Hern.-Mar., Gómez-Bolea & Llimona

Specimens examined. Hanzo: YO14066 (on soil among rocks of stone wall, 13 April 2022). Kanbaku: MS1102 (on rock, 6 December 2022). Shimodokan: MS1037 (on stone wall, 10 March 2022).

21. **Buellia* cf. *mamillana* (Tuck.) W.A. Weber

(Fig. 3A)

The BLAST result for the ITS sequence of specimen YO14382 shows a high similarity (99.42%) to *Buellia mamillana* from South Korea (GenBank KT733600; Wang *et al.*, 2016). This species was originally described based on the specimen growing on a volcanic rock in O'ahu Island, Hawai'i (Tuckerman, 1866). Since the locality is phytogeographically distant from East Asia, careful taxonomic examination is required to determine whether the specimens are truly conspecific with *B. mamillana*. Therefore, it is treated here as *Buellia* cf. *mamillana*.

Specimen examined. Nishihane: YO14382 (on stone wall, 27 February 2024).

22. ***Buellia*** sp. 1

The species is characterized by the immersed apothecia and the minutely warted, 1-septated, brown spores (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

23. ***Buellia*** sp. 2

This species is characterized by the sorediate thallus with black apothecia (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

24. ***Caloplaca*** sp.

It was reported as "*Caloplaca* sp. 2" in Ohmura *et al.* (2014).

Not confirmed during 2021–2025 survey.

25. ***Candelaria asiatica*** D. Liu & J.S. Hur

Specimens examined. Agency: MS1022 (on bark of *Zelkova serrata*, 10 December 2021). Hanzo: MS1056 (on stone wall, 13 April 2022). Inui: MS959 (on base of *Cerasus* × *yedoensis*, 29 September 2021), YO13965 (on concrete, 29 September 2021). Kitanomaru: YO14277 (on bark of *Cerasus speciosa*, 6 June 2023), YO14297 (on trunk of *Zelkova serrata*, 6 June 2023). Nakadokan: YO14131, YO14143 (on stone wall, 20 May 2022).

26. *†Candelariella xanthostigmoides* (Müll. Arg.) R.W. Rogers

(Fig. 3B)

It was previously reported as "*Candelariella* sp." in Ohmura *et al.* (2014), but these specimens have now been identified as *C. xanthostigmoides*.

Specimens examined. Inui: MS967 (on bark of *Pinus thunbergii*, 29 September 2021), YO9560 (on bark of *Cerasus* × *yedoensis*, 6 March 2013), YO14383 (on bark of *Pinus thunbergii*, 27 February 2024), YO14705 (on bark of *Pinus thunbergii*, 30 April 2025). Kitanomaru: YO14289, YO14290 (on bark of *Cerasus* sp., 6 June 2023).

27. **Canoparmelia aptata* (Kremp.) Elix & Hale

(Fig. 3C)

Specimens examined. Inui: MS953 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO14375 (on trunk of *Cerasus* sp., 27 February 2024). Dokan-Shin: MS1019 (on bark of *Cerasus* × *yedoensis*, 10 December 2021).

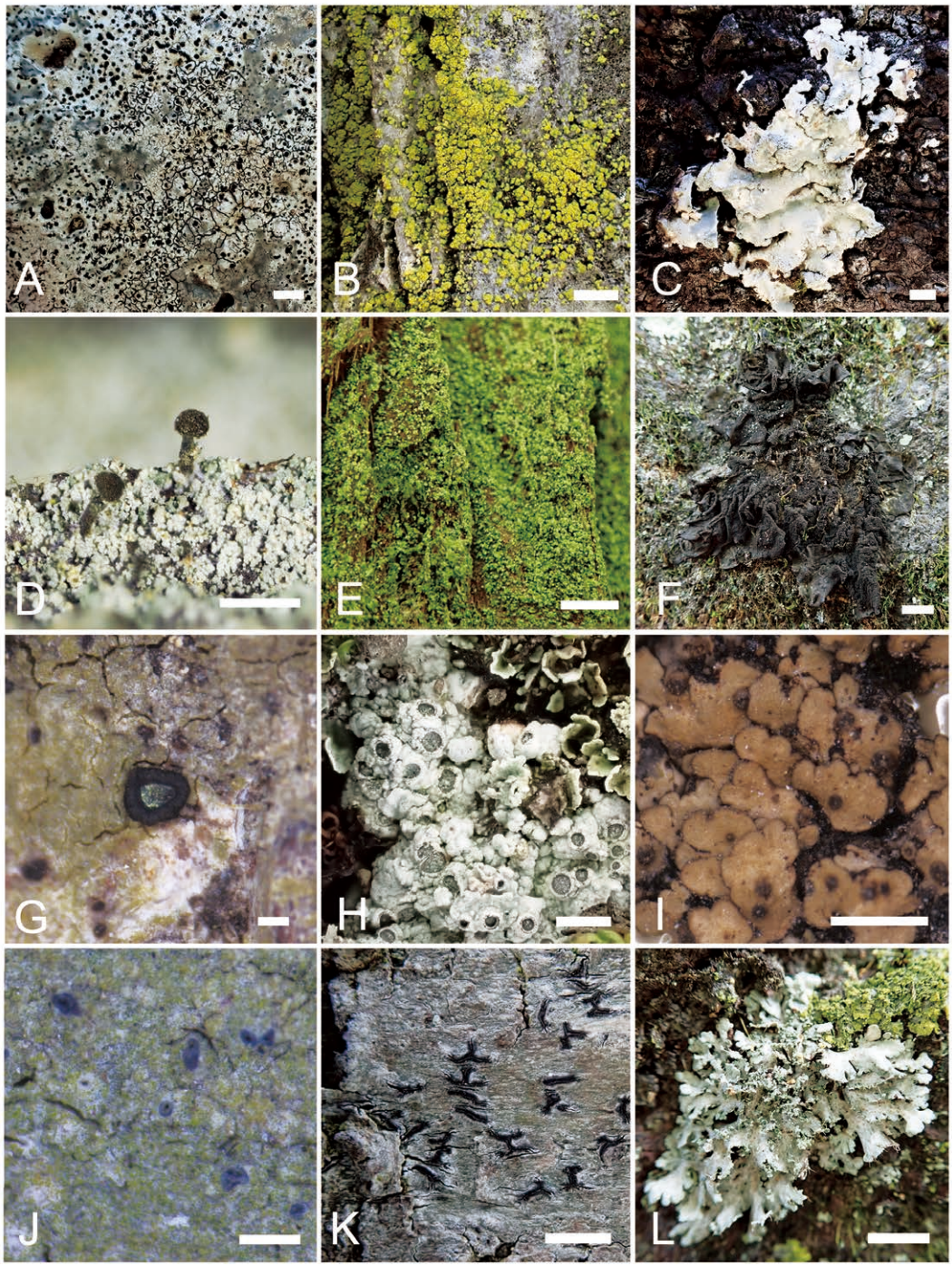

Fig. 3. Selected images of lichens from the Imperial Palace Grounds. A. *Buellia* cf. *mamillana* (YO14382). B. *Candelariella xanthostigmoides* (YO14383). C. *Canoparmelia aptata* (YO14375). D. *Chaenotheca hygrophila* (YO14118). E. *Chrysothrix* sp. (MS1065). F. *Collema subflaccidum* (MS1084). G. *Cresponea macrocarpoides* (MS1036). H. *Diploschistes muscorum* (YO14360). I. *Endocarpon nigromarginatum* (MS1038). J. *Fellhanera* sp. 2 (YO14033). K. *Graphis lineola* (YO14483). L. *Heterodermia microphylla* (MS1081). Scales: A, C = 2 mm. B, D, E, H, I, K = 1 mm. F, L = 5 mm. G, J = 200 μm.

28. ***Chaenotheca hygrophila*** Tibell

(Fig. 3D)

Specimen examined. Kamidokan: YO14118 (on trunk of *Cryptomeria japonica*, 20 May 2022).

29. ***Chaenothecopsis nigra*** Tibell

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

30. ***Chrysothrix*** sp.

(Fig. 3E)

This species resembles *Chrysothrix flavovirens* Tønsberg but differs in lacking an unknown substance detected in European populations (Ohmura *et al.*, 2014).

Specimens examined. Inui: MS974 (on base of *Acer buergerianum*, 29 September 2021). Kamidokan: MS1065 (on bark of *Cryptomeria japonica*, 20 May 2022), YO9597 (on bark of *Pinus thunbergii*, 8 March 2013). Kashiko: YO14365 (on bark of *Cinnamomum camphora*, 27 June 2023).

31. ***Cladonia caespiticia*** (Pers.) Flörke

Specimens examined. Bairinzaka-HG: YO14378 (on stone wall, 27 February 2024). Inui: YO13971 (on stone wall, 20 May 2022), YO14703 (on trunk of *Pinus thunbergii*, 30 April 2025). Nakadokan: MS1077, YO14138 (on stone wall, 20 May 2022). Sankaku: MS1059 (on rock with mosses on stone wall, 13 April 2022).

32. ***Cladonia kurokawae*** Ahti & S. Stenroos

Specimens examined. Fujimi-HG: YO14338 (on stone wall, 7 February 2023). Hanzo: MS1053, MS1058 (on soil among rocks of stone wall, 13 April 2022). Inui: MS968 (on base of *Pinus thunbergii*, 29 September 2021), MS979 (on plant debris on stone wall, 29 September 2021), YO13976 (on stone wall with mosses, 29 September 2021), YO14704 (on trunk of *Pinus thunbergii*, 30 April 2025). Kamidokan: YO14124 (on trunk base of *Pinus thunbergii*, 20 May 2022), MS1072 (on bark of *Pinus thunbergii*, 20 May 2022). Kanko: MS1033 (on bark of *Pinus thunbergii*, 10 March 2022). Kashiko: YO14361 (on soil, 27 June 2023). Kitanomaru: YO14294 (on trunk base of *Cerasus* sp., 6 June 2023). Sakashita: YO14334 (on mosses on stone wall, 17 January 2023). Sankaku: MS1135 (on plant debris, 7 February 2023), YO14346 (on concrete with mosses, 7 February 2023).

33. ***Cladonia rei*** Schaer.

Specimen examined. Ohmichi: MS1103 (on soil, 6 December 2022).

34. ***Coenogonium dilucidum*** (Kremp.) Kalb & Lücking

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

35. ***Coenogonium kawanae*** (H. Harada & Vězda) H. Harada & Lumbsch

Specimen examined. Kanbaku: MS1095 (on bark of *Cercidiphyllum japonicum*, 6 December 2022).

36. ***Coenogonium pineti*** (Ach.) Lücking & Lumbsch

Specimens examined. Fukiage: YO9576 (on trunk base of *Pinus thunbergii*, 7 March 2022). Hakucho: MS1091 (on decayed wood, 6 December 2022). Kain-tei: MS1034 (on trunk base of *Pinus thunbergii*, 10 March 2022), MS1035 (on trunk base of *Pinus densiflora*, 10 March 2022). Kanko: YO14038 (on trunk base of *Pinus thunbergii*, 10 March 2022). Momijiyama: MS1120 (on trunk base of *Pinus densiflora*, 17 January 2023). Oike: MS1007 (on rock, 10 December 2021).

37. ****Collema subflaccidum*** Degel.

(Fig. 3F)

Specimens examined. Inui: MS977 (on stone wall, 29 September 2021). Kamidokan: MS1084 (on stone wall, 20 May 2022).

38. ***Cresponea japonica*** A. Sakata & H. Harada

Specimens examined. Chikurin: YO14048, YO14051 (on bark of *Acer buergerianum*, 13 April 2022).

39. ****Cresponea macrocarpoides*** (Zahlbr.) Egea & Torrente

(Fig. 3G)

Specimen examined. MS1036 (on bark

of *Cornus kousa*, 10 March 2022).

40. ***Dendrographa decolorans*** (Sm.) Ertz & Tehler

This species also includes "Lichen sp. 3" in Ohmura *et al.* (2014) [= "Lichen sp. #4" in Kashiwadani and Thor (2000)], and correct identification was made in Handa *et al.* (2014).

Specimens examined. Hanzo: YO14076 (on stone wall, 13 April 2022). Kanbaku: YO13986 (on bark of *Celtis sinensis*, 10 December 2021), YO13989 (on bark of *Magnolia kobus*, 10 December 2021).

41. **Diploschistes muscorum*** (Scop.) R. Sant. (Fig. 3H)

Specimen examined. Kashiko: YO14360 (on *Cladonia kurokawae* and/or soil, 27 June 2023).

42. ***Dirinaria applanata*** (Fée) D.D. Awasthi

Specimens examined. Agency: YO14008 (on bark of *Zelkova serrata*, 10 December 2021). Inui: MS964 (on bark of *Pinus thunbergii*, 29 September 2021), YO14376 (on bark of *Cerasus* sp., 27 February 2024). Kikyo: YO14343 (on trunk of *Cinnamomum camphora*, 7 February 2023). Kitanomaru: YO14291 (on bark of *Cerasus* sp., 6 June 2023). Nakadokan: MS1080 (on stone wall, 20 May 2022).

43. ***Endocarpon japonicum*** H. Harada

Specimens examined. Hanzo: YO14056 (on stone wall, 13 April 2022). Inui: MS978 (on stone wall, 29 September 2021), MS981 (on concrete, 29 September 2021). Kamidokan: MS1086 (on stone wall, 20 May 2022).

44. ***Endocarpon neopallidulum*** H. Harada

Specimens examined. Hakucho: MS1094 (on rock, 6 December 2022). Inui: YO9561 (on trunk base of *Acer palmatum*, 6 March 2013). Oike: MS1015, YO14002 (on rock, 10 December 2021).

45. **Endocarpon nigromarginatum*** H. Harada (Fig. 3I)

Specimens examined. Agency: MS1038 (on concrete wall, 10 March 2022). Sankaku: YO14344 (on concrete, 7 February 2023).

46. ***Endocarpon petrolepideum*** (Nyl.) Nyl.

Specimens examined. Inui: YO13977 (on stone wall, 29 September 2021). Shokomon: MS1115 (on concrete, 17 January 2023).

47. ***Endocarpon superpositum*** H. Harada

This species is distinguished from *E. japonicum* by its loosely attached and overlapping squamules, whereas those of the latter species are tightly adnate, contiguous, and radiately branched (Harada, 1993). However, it is sometimes difficult to distinguish them because intermediate forms occur and the ITS sequences do not clearly separate according to the species concept. A detailed taxonomic re-examination is therefore needed to clarify their independence.

Specimen examined. Hanzo: YO14056 (on stone wall, 13 April 2022).

48. ***Enterographa anguinella*** (Nyl.) Redinger

Specimens examined. Hakucho: YO14233 (on bark of *Cercidiphyllum japonicum*, 6 December 2022). Kitanomaru: YO14284 (on bark of *Platanus* × *acerifolia*, 6 June 2023).

49. ***Enterographa hutchinsiae*** (Leight.) A. Massal.

Specimen examined. Sankaku: MS1060 (on stone wall, 13 April 2022).

50. ***Fellhanera*** sp. 1

For a detailed description, see that of "*Fellhanera* sp." in Kashiwadani and Thor (2000). See also Ohmura *et al.* (2014).

Not confirmed during 2021–2025 survey.

51. ***Fellhanera*** sp. 2 (Fig. 3J)

For a detailed description, see Ohmura *et al.* (2014). This species is distinguished from *Fellhanera* sp. 1 by the thallus color and conidia size (green thallus and 4–6 × 1–1.5 µm conidia for *Fellhanera* sp. 2 vs. bluish tint thallus and 3–4 × 2 µm conidia for *Fellhanera* sp. 1).

Specimen examined. Hakucho: YO14033

(on wooden bridge, 10 March 2022).

52. ***Flavoparmelia caperata*** (L.) Hale

Specimens examined. Dokan-Shin: YO14756 (on branch of *Quercus acutissima*, 12 June 2025, coll.: J. Kosugi). Inui: YO13942 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO13953 (on bark of *Prunus lannesiana* 'Sekiyama', 29 September 2021), YO13969 (on stone wall, 29 September 2021), YO14369 (on trunk of *Cerasus itosakura*, 27 February 2024). Kitanomaru: YO14280 (on bark of *Cerasus serrulata*, 6 June 2023).

53. ***Flavoplaca flavocitrina*** (Nyl.) Arup, Frödén & Søchting

Specimen examined. Kyuden: MS1122 (on rock, 17 January 2023). Sankaku: MS1061 (on concrete, 13 April 2022).

54. ***Graphis deserpens*** Vain.

(Fig. 7H, I)

It was collected in Kitanomaru Park, not found in the Imperial Palace Grounds.

Specimens examined. Kitanomaru: YO14302, YO14304 (on bark of *Carpinus* sp., 6 June 2023).

55. ***Graphis handelii*** Zahlbr.

Specimens examined. Dokan-Shin: YO14005 (on bark of *Cerasus* × *yedoensis*, 10 December 2021), Fukiage: (on bark of *Prunus mume*, 26 October 2009). Hakucho: YO14234 (on branches of *Cercidiphyllum japonicum*, 6 December 2022). Inui: MS955, YO13945 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), MS970, MS971 (on bark of *Acer palmatum*, 29 September 2021), YO14373 (on bark of *Acer palmatum*, 27 February 2024), YO14485 (on bark of *Acer palmatum* 'Nomura', 16 December 2024), YO14490 (on bark of *Cercidiphyllum japonicum*, 16 December 2024), YO14493 (on bark of *Acer palmatum*, 16 December 2024), YO14496 (on bark of *Cerasus incisa*, 16 December 2024), YO14497 (on bark of *Cerasus serrulata* 'Nigrescens', 16 December 2024), YO14498 (on bark of *Cerasus jamasakura*, 16 December 2024). Kanbaku: YO9581 (on trunk of *Cercidiphyllum japonicum* f. *pendula*, 7 March 2013), YO13988 (on bark of *Pyracantha coccinea*, 10 December 2021). Kanko: YO14035 (on bark of *Pyrus pyrifolia* var. *culta*, 10 March 2022). Kitanomaru: YO14295 (on bark of *Zelkova serrata*, 6 June 2023). Tomodamari: YO14337 (on bark of *Osmanthus fragrans* var. *auranti-acus*, 7 February 2023).

56. ****Graphis lineola*** Ach.

(Fig. 3K)

Specimens examined. Inui: YO14483 (on bark of *Cerasus spachiana* 'Jind-ai-akebono', 16 December 2024). Kanbaku: MS1096 (on bark of *Cercidiphyllum japonicum*, 6 December 2022).

57. ***Graphis scripta*** (L.) Ach.

Specimen examined. Inui: YO14495 (on bark of *Acer amoenum*, 16 December 2024).

58. ****Heterodermia microphylla*** (Kurok.) Skorepa

(Fig. 3L)

Specimens examined. Nakadokan: MS1078, MS1081, YO14133 (on stone wall, 20 May 2022).

59. ***Hyperphyscia crocata*** Kashiw.

Specimens examined. Fukiage: YO8190 (on trunk base of *Acer palmatum*, 21 April 2011). Hanzo: YO14071 (on stone wall, 13 April 2022). Inui: YO13949 (on base of *Cerasus* × *yedoensis*, 29 September 2021), YO13961 (on bark of *Acer palmatum*, 29 September 2021), YO13963 (on bark of *Acer buergerianum*, 29 September 2021), YO13974 (on stone wall with mosses, 29 September 2021). Kamidokan: MS1085, YO14145 (on stone wall, 20 May 2022). Kitanomaru: YO14286 (on bark of *Zelkova serrata*, 6 June 2023). Oike: MS1004 (on bark of *Acer* sp., 10 December 2021).

60. ***Hypotrachyna minarum*** (Vain.) Krog & Swinscow

Specimens examined. Hisago: YO14348 (on bark of *Cedrus deodara*, 7 February

2023). Inui: YO13943 (on bark of *Cerasus* × *yedoensis*, 29 September 2021). Kashiko: YO14047 (on trunk of *Cerasus* × *yedoensis*, 13 April 2022).

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

(Fig. 4A)

Specimens examined. Hisago: YO14349 (on bark of *Cedrus deodara*, 7 February 2023). Kashiko: YO14362 (on trunk base of *Cinnamomum camphora*, 27 June 2023).

62. ***Inoderma nipponicum*** Frisch, Y. Ohmura & G. Thor

Specimen examined. Chikurin: MS1040 (on bark of *Acer buergerianum*, 13 April 2022).

63. **Ionaspis lacustris* (With.) Lutzoni

(Fig. 4B)

Specimen examined. Kain-tei: YO14040 (on rock, 10 March 2022).

64. ***Kashiwadia orientalis*** (Kashiw.) S.Y. Kondr., Lőkös & Hur

Specimens examined. Dokan-Shin: MS1020 (on bark of broadleaf deciduous tree, 10 December 2021). Hanzo: MS1054 (on stone wall, 13 April 2022). Kamidokan: YO14147 (on stone wall, 20 May 2022). Inui: YO13944 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO14377 (on bark of *Pinus thunbergii*, 27 February 2024), YO14702 (on trunk of *Pinus thunbergii*, 27 February 2024). Kitanomaru: YO14276 (on bark of *Cerasus campanulata*, 6 June 2023), YO14283 (on bark of *Cerasus serrulata*, 6 June 2023), YO14285 (on bark of *Zelkova serrata*, 6 June 2023). Nakadokan: MS1079, YO14139 (on stone wall, 20 May 2022).

65. ***Lecania erysibe*** (Ach.) Mudd

Specimens examined. Hanzo: MS1043, YO14062 (on stone wall, 13 April 2022). Inui: MS987 (on stone, 29 September 2021). Kamidokan: MS1087 (on stone wall, 20 May 2022). Kyuden: YO14332 (on rock, 17 January 2023).

66. ***Lecanora japonica*** Müll. Arg.

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

67. ***Lecanora leprosa*** Fée

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

68. *+Lecanora neobarkmaniana* J. S. Park & S. O. Oh

Japanese common name newly proposed: *Kofuki-iwa-chashibu-goke*

(Fig. 4C)

This is a saxicolous sorediate species [reported as "*Lecanora* sp. #1" in Kashiwadani and Thor (2000); "*Lecanora* sp." in Ohmura *et al.* (2014)]. Its morphology, chemistry and the ITS sequences are in agreement with those of this species (Park *et al.*, 2023).

Specimens examined. Hanzo: MS1052, YO14054, YO14057, YO14067, YO14068, YO14075 (on stone wall, 13 April 2022), YO7660, YO7671 (on stone wall, 13 October 2010), YO7665, YO7668 (on rock, 13 October 2010), YO9584 (on stone wall, 7 March 2013). Kamidokan: YO7675, YO7678, YO7681, YO7691, YO7692 (on stone wall, 13 October 2010). Kanbaku: MS1100 (on rock, 6 December 2022).

69. *+Lecanora pseudargentata* Lumbsch

Japanese common name newly proposed: *Nise-hime-chashibu-goke*

(Fig. 4D)

This species resembles *L. argentata* (Ach.) Malme by the apothecial morphology and secondary chemistry, both producing atranorin and gangaleoidin. However, it differs by having a *chlarotera*-type epihymenium with fine granules which dissolves after applying KOH, while *L. argentata* has a *glabrata*-type epihymenium that is smooth and non-granular (Lumbsch, 1994). The Japanese specimen showed 99% identity in the ITS sequences to *L. pseudargentata* (MH714514, MH714515, OQ832601; Wirth *et al.*, 2018, Li *et al.*, 2023). The epihymenium exhibited only scattered granules, but the remaining morphological characters agreed well with this species.

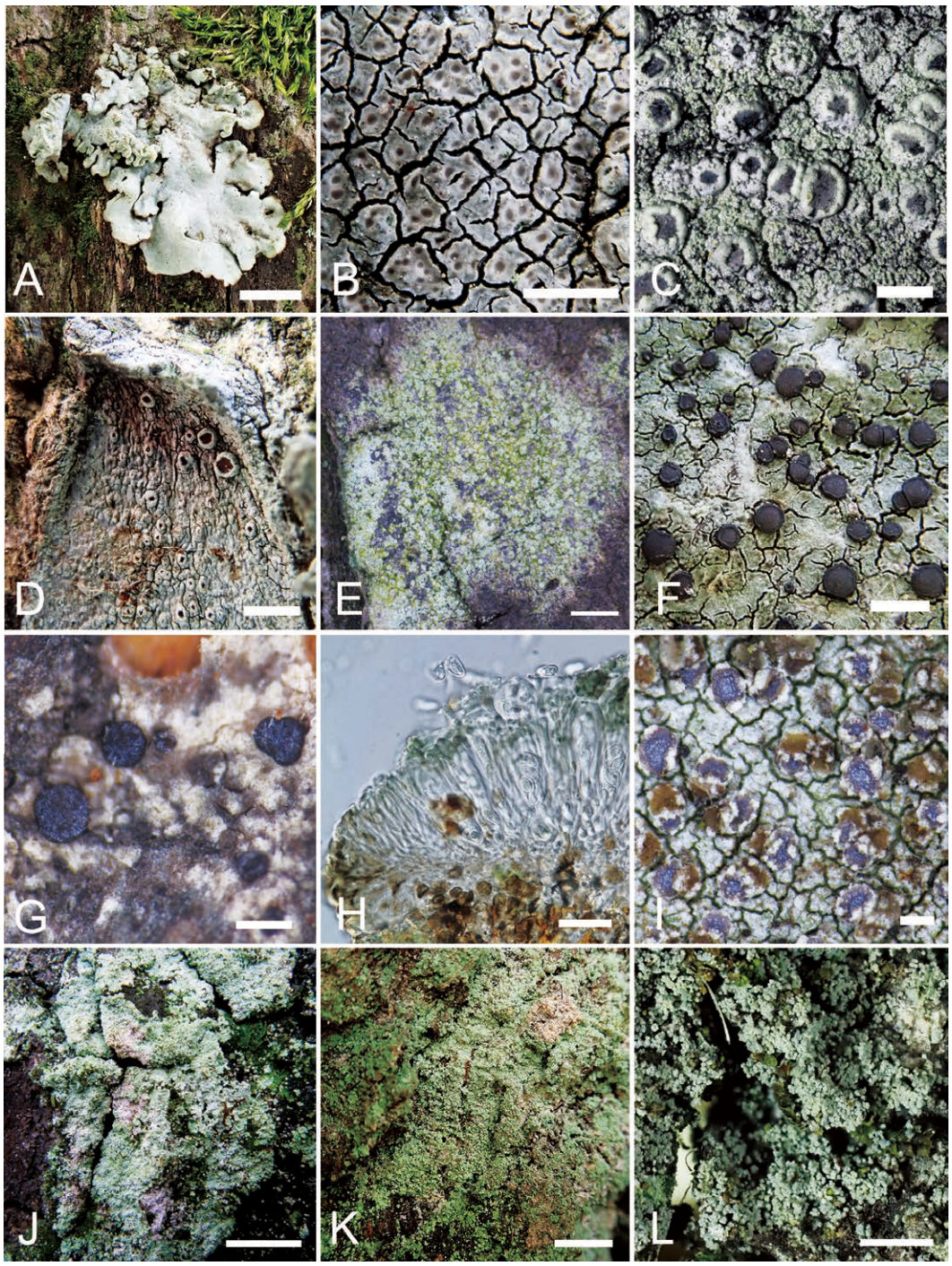

Fig. 4. Selected images of lichens from the Imperial Palace Grounds. A. *Hypotrachyna spumosa* (YO14349). B. *Ionaspis lacustris* (YO14040). C. *Lecanora neobarkmaniana* (MS1052). D. *Lecanora pseudargentata* (YO14492). E. *Lecanora* sp. (YO14126). F. *Lecidea* sp. 4 (YO14044). G–H. *Lecidella elaeochroma* var. *caesitia* (YO8429) (G: apothecia and thallus, H: cross section of apothecium and ascospores). I. *Lecidella* sp. (YO14486). J. *Lepraria finkii* (YO6812). K. *Lepraria* sp. 1 (YO14236). L. *Leprocaulon adhaerens* (YO13947). Scales: A = 2 mm. B–F, L = 1 mm. G, I = 200 µm. H = 20 µm. J = 1 cm. K = 5 mm.

Specimen examined. Inui: YO14492 (on bark of *Cerasus itosakura* f. *ascendens*, 16 December 2024).

70. ***Lecanora pulverulenta*** Müll. Arg.

Specimens examined. Inui: AF12/Jp41 (on bark of *Acer buergerianum*, 1 December 2011), MS961 (on bark of *Pinus thunbergii*, 29 September 2021), MS969 (on bark of *Acer palmatum*, 29 September 2021), YO13948 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO13981 (on wooden plate, 29 September 2021), YO14385 (on bark of *Pinus thunbergii*, 27 February 2024), YO14487 (on bark of *Cercidiphyllum japonicum*, 16 December 2024). Kitanomaru: YO14275 (on bark of *Cerasus serrulata*, 6 June 2023). Ohmichi: YO14246 (on twig of *Cerasus itosakura*, 6 December 2022).

71. **Lecanora* sp.

(Fig. 4E)

This species has a mainly sterile, sorediate crustose thallus containing usnic acid, with rare apothecia observed. This species is not the same as the "*Lecanora* sp." described in Ohmura *et al.* (2014). The ITS sequence of the Japanese specimens showed ca. 94% identity to *Lecanora stanislai* Guzow-Krzem., Łubek, Malíček & Kukwa (KY586039, Guzow-Krzemińska *et al.*, 2017). Although it seems to be related to the fertile species *L. pulverulenta*, *L. strobilina* (Spreng.) Kieff., and *L. strobilinoides* Giralt & Gómez-Bolea, as well as to the sterile *L. stanislai*, the taxonomic relationships among these taxa still require further study.

Specimens examined. Inui: MS965 (on bark of *Pinus thunbergii*, 29 September 2021). Kamidokan: YO14126 (on bark of *Pinus thunbergii*, 20 May 2022).

72. ***Lecidea*** sp. 1

This species is characterized by a green, gelatinous thallus, greyish brown apothecia up to 0.8 mm in diameter with a constricted base, a brownish black hypothecium, an I+ blue hymenium, colorless, non-septate ascospores (15 × 7 µm), and the absence of secondary substances by TLC (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

73. ***Lecidea*** sp. 2

This species is characterized by a pale greenish grey, thin to evanescent thallus (K+ yellow, C+ yellow-orange, Pd–), small, sparse apothecia 0.1–0.15 mm in diameter with a brown, weakly glossy disc and an elevated concolorous margin, and rare ascospores (6–7 × 3–4 µm) (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

74. ***Lecidea*** sp. 3

This species resembles *Lecidea lapicida* (Ach.) Ach. but is characterized by a white, rimose to irregularly areolate thallus (K+ yellow, C–, Pd–, I–, UV–); small black apothecia up to 0.1 mm in diameter with a green epithecium; simple, hyaline, ellipsoid ascospores (11.0 × 5.0–5.8 µm); and the presence of atranorin, planaic acid, and an unidentified pale Rf class 3 substance (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

75. **Lecidea* sp. 4

(Fig. 4F)

The ITS sequence of this species showed 87.59% similarity to *Lecidea albohyalina* (Nyl.) Th. Fr. (OQ717907; Vondrák *et al.*, 2023), a low value indicating that its taxonomic position remains uncertain.

Specimens examined. Inui: YO13978 (on stone wall, 29 September 2021). Shimodokan: YO14044 (on rock, 10 March 2022).

76. **Lecidella elaeochroma* (Ach.) M. Choisy var. ***caesitia*** (Vain.) Mas. Inoue

(Fig. 4G–H)

This species was found among the unidentified specimens collected in 2011, but it was not confirmed during the present survey conducted in 2021–2025.

Specimen examined. Fukiage: YO8429

(on bark of *Prunus mume*, 1 December 2011).

77. ***Lecidella enteroleucella*** (Nyl.) Hertel

Specimens examined. Hanzo: MS1042, MS1057, YO14061, YO14069 (on stone wall, 13 April 2022). Inui: YO13979 (on stone wall, 29 September 2021). Kamidokan: YO14149 (on stone wall, 20 May 2022). Nakadokan: YO14140, YO14141 (on stone wall, 20 May 2022). Ohmiya: YO14042 (on rock, 10 March 2022). Sakashita: YO14325 (on rock, 17 January 2023).

78. **Lecidella* sp.

(Fig. 4I)

The ITS and mtSSU sequences of this species showed 85.81% and 99.17% similarity to *Lecidella albida* Hafellner (KX132964, OK465664; Mark *et al.*, 2016, Vondrák *et al.*, 2022), respectively. However, the low ITS similarity and the lack of comparison with reference specimens require further study before its taxonomy can be clarified.

This species was also found among the unidentified specimens collected in the previous survey in 2009 and 2011.

Specimens examined. Fukiage: YO6805 (on bark of *Cerasus jamasakura*, 26 October 2009), YO8428 (on bark of *Prunus mume*, 1 December 2011). Inui: YO8440 (on bark of *Cercidiphyllum japonicum*, 1 December 2011), YO14372 (on bark of *Cerasus* × *yedoensis*, 27 February 2024), YO14486 (on bark of *Acer palmatum* 'Nomura', 16 December 2024), YO14488, YO14489 (on bark of *Cercidiphyllum japonicum*, 16 December 2024), YO14500 (on bark of *Acer amoenum* 'Oosakazuki', 16 December 2024).

79. ***Lepraria cupressicola*** (Hue) J.R. Laundon

Specimens examined. Fujimi-HG: MS1129 (on rock, 7 February 2023), YO14339 (on stone wall, 7 February 2023). Fukiage: MS993 (on bark of *Prunus* sp., 10 December 2021). Inui: MS966, YO13952 (on bark of *Pinus thunbergii*, 29 September 2021), YO13955 (on bark of *Prunus lannesiana* 'Sekiyama', 29 September 2021). Kamidokan: MS1064, YO14121 (on bark of *Cryptomeria japonica*, 20 May 2022). Kanbaku: YO13987 (on bark of *Prunus spachiana* f. *ascendens*, 10 December 2021), YO13991 (on rock with mosses, 10 December 2021). Kikyo: MS1131 (on trunk base of *Pinus densiflora*, 7 February 2023). Momijiyama: YO14327 (on trunk base of *Castanopsis sieboldii*, 17 January 2023). Nakadokan: YO14130, YO14137 (on stone wall, 20 May 2022). Sankaku: YO14079, YO14080 (on stone wall, 13 April 2022). Yamazato: YO14329 (on stone wall, 17 January 2023).

80. *†Lepraria finkii* (B. de Lesd.) R.C. Harris

(Fig. 4J)

This species was reported as "*Lepraria lobificans* Nyl." in Ohmura *et al.* (2014), but following Lendemer (2013), the specimens from the Imperial Palace Grounds are treated here as *L. finkii*.

Specimens examined. Chikurin: YO14050 (on bark of *Acer buergerianum*, 13 April 2022). Fukiage: YO13983 (on bark of *Liquidambar styraciflua*, 10 December 2021). Hanzo: MS1049, YO14064 (on soil among rocks of stone wall, 13 April 2022). Inui: YO13975 (on stone wall with mosses, 29 September 2021). Kanbaku: YO6812 (on bark of *Liquidambar formosana*, 26 October 2009).

81. ***Lepraria vouauxii*** (Hue) R.C. Harris

Specimen examined. Kamidokan: YO14148 (on stone wall, 20 May 2022).

82. ***Lepraria*** sp. 1

(Fig. 4K)

This species is characterized by the absence of a bluish thallus and a whitish medulla, by its more cottony thallus, and by the presence of atranorin, zeorin and stictic acid complex (Kashiwadani and Thor, 2000; Ohmura *et al.*, 2014). The ITS sequence showed 92.86–95.07% similarity to *Lepraria ulrikii* Grewe, Barcenas-Peña, R.

Diaz & Lumbsch (MZ820304, MZ820307; Barcenas-Peña *et al.*, 2021). It shows certain similarities, but its taxonomic placement remains uncertain and requires further study.

Specimens examined. Hakucho: YO14236 (on trunk base of *Carpinus tschonoskii*, 6 December 2022). Hanzo: MS1050, YO14065 (on soil among rocks of stone wall, 13 April 2022).

83. [+]***Leprocaulon adhaerens*** (K. Knudsen, Elix & Lendemer) Lendemer & B.P. Hodk.

Japanese common name newly proposed: *Nise-rokushô-kona-chii*

(Fig. 4L)

This species is characterized by a blue-gray, adherent leprose thallus composed of tightly coherent granules (40–100 µm diameter), and by a chemical profile with pannarin, zeorin, ±atranorin, and other accessory substances such as norpannarin, dechloropannarin and hypopannarin (Knudsen *et al.*, 2007). The morphology and chemistry of Japanese specimen agree well with the diagnostic characteristics, and the ITS sequence shows 98.16% similarity to this species (KC184097; Lendemer and Hodkinson, 2013).

Specimen examined. Inui: YO13947 (on bark of *Cerasus* × *yedoensis*, 29 September 2021).

84. [+]***Leprocaulon nicholsiae*** Lendemer & E. Tripp

Japanese common name newly proposed: *Rokushô-kona-chii*

(Fig. 5A)

This species corresponds to "*Lepraria* sp. 2" and "*Lepraria* sp. 3" in Ohmura *et al.* (2014). This species is characterized by its adpressed, dull greenish-grey thalli forming irregular patches up to several centimeters across, and by the presence of usnic acid, zeorin and unknown minor substances (Kashiwadani and Thor, 2000; Ohmura *et al.*, 2014). The morphology and chemistry of Japanese specimen agree well with the diagnostic characteristics of *L. nicholsiae* (Tripp and Lendemer, 2019), and the ITS sequences are also high similarity 98.90–99.58% (MN580180, OL472385, OR651772).

Specimens examined. Hakucho: YO14031 (on bark of *Acer palmatum*, 10 March 2022). Honmaru: YO14379 (on bark of *Cerasus* × *yedoensis*, 27 February 2024). Inui: YO6834, YO6839 (on bark of *Acer buergerianum*, 3 December 2009), YO13951 (on bark of *Pinus thunbergii*, 29 September 2021). Kikyo: MS1132 (on trunk base of *Pinus densiflora*, 7 February 2023). Kitanomaru: YO14300 (on bark of *Cinnamomum camphora*, 6 June 2023). YO14305 (on bark of *Prunus* sp., 6 June 2023). Ohmiya: YO14043 (on rock, 10 March 2022). Oike: YO13999 (on rock, 10 December 2021), YO14011 (on bark of *Zelkova serrata*, 10 December 2021). Sankaku: MS1062 (on bark of *Acer buergerianum*, 13 April 2022), YO14078 (on stone wall, 13 April 2022).

85. [*]***Leptogium azureum*** (Sw. ex Ach.) Mont.

(Fig. 5B)

Specimen examined. Kamidokan: YO14144 (on stone wall, 20 May 2022).

86. [§*]***Lichenochora*** sp.

(Fig. 5C)

This is a lichenicolous fungus characterized by numerous small ascomata (120–160 µm diam.) immersed in galls and by its ellipsoid, hyaline, 1-septate, relatively small ascospores (12–16.2 × 5.2–6.8 µm). Although the specimen resembles *L. aipoliae* Etayo, Nav.-Ros. & Coppins and *L. obscuroides* (Linds.) Triebel & Rambold, a detailed taxonomic study, including the evaluation of the independence of these taxa, is needed. Accordingly, the present material is treated at the genus level in this study.

Specimen examined. Inui: YO6835 pr.p. (on *Physciella melanchra* on bark of *Acer buergerianum*, 3 December 2009).

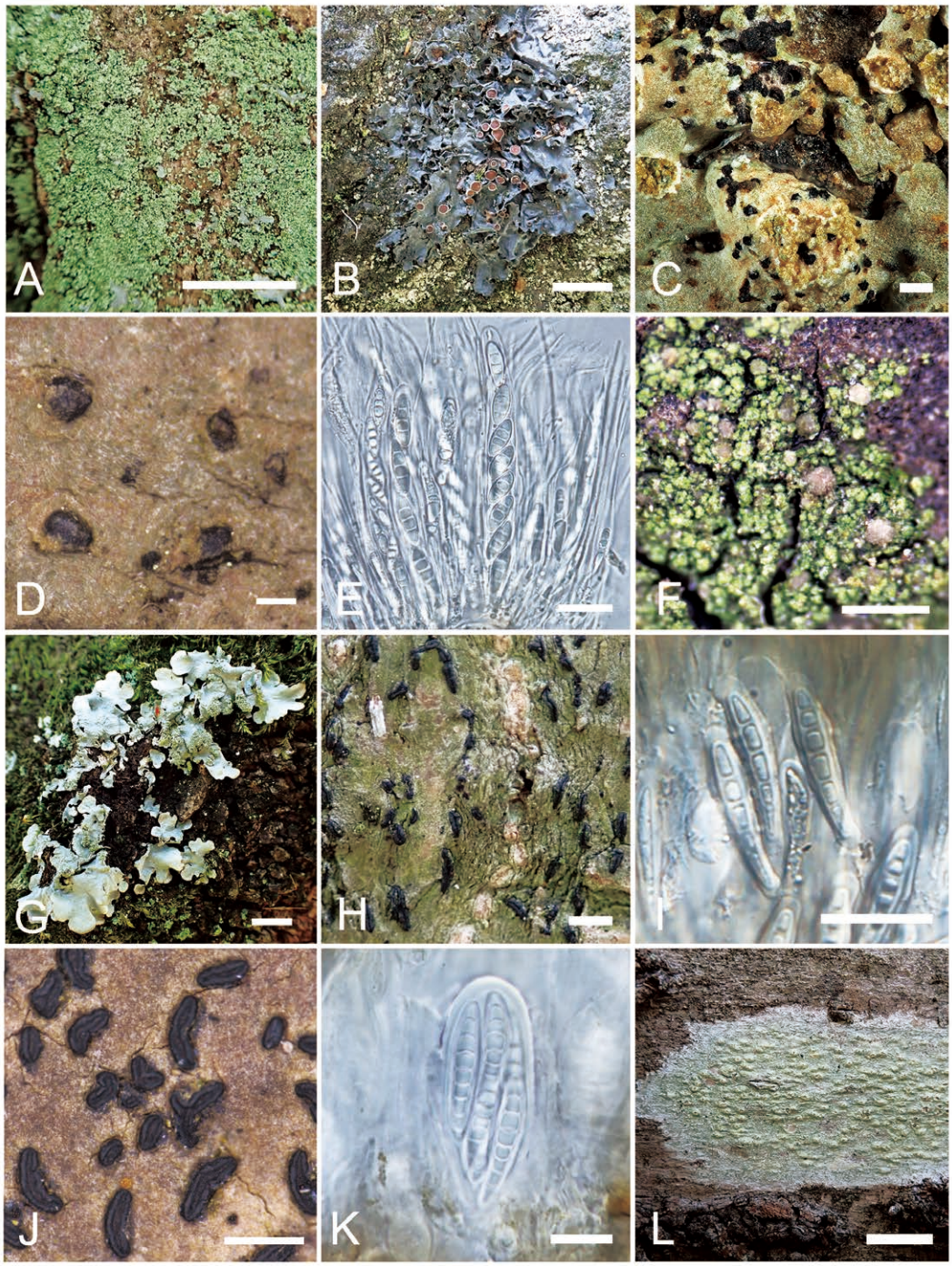

Fig. 5. Selected images of lichens from the Imperial Palace Grounds. A. *Leprocaulon nicholsiae* (MS1062). B. *Leptogium azureum* (YO14144). C. *Lichenochora* sp. on *Physciella melanchra* (YO6835 pr.p.). D. *Lithothelium japonicum* (YO13982). E. Ascospores of *Lithothelium japonicum* (YO14049). F. *Micarea* sp. 1 (MS1121). G. *Myelochroa aurulenta* (YO14706). H. *Opegrapha* sp. 1 (MS995). I. Ascospores of *Opegrapha* sp. 1 (YO14235). J. *Opegrapha* sp. 3 (MS1027). K. Ascospores of *Opegrapha* sp. 3 (MS1027). L. *Pertusaria pustulata* (YO14006). Scales: A, B, G, L = 5 mm. C = 200 µm. D, F, J = 0.5 mm. E, I = 20 µm. H = 1 mm. K = 10 µm.

87. §***Lichenothelia*** sp. 1

This is a saxicolous non-lichenized fungus, and characterized by a black thallus composed of scattered areoles up to 0.1 mm in diameter; a hymenium with I+ pale blue in parts, K–, and KI/I+ pale blue; and 8-spored asci. The ascospores are colorless to pale brown, smooth, 1-septate, constricted at the septum with one cell slightly larger (8–10 × 5 µm). Pycnidia were not observed. See Ohmura *et al.* (2014).

Not confirmed during 2021–2025 survey.

88. §***Lichenothelia*** sp. 2

This is a non-lichenized fungus, and is distinguished from *Lichenothelia* sp. 1 by the aggregated areoles and the larger spores (14 × 6 µm) (Ohmura *et al.*, 2014).

Specimen examined. Hanzo: YO14074 (on stone wall, 13 April 2022).

89. ***Lichinella japonica*** H. Harada & Hensen

Specimens examined. Sankaku: MS1134 (on concrete, 7 February 2023).

90. ***Lithothelium japonicum*** H. Harada

(Fig. 5D–E)

Specimens examined. Chikurin: MS1041, YO14052 (on bark of *Acer buergerianum*, 13 April 2022), YO14049 (on trunk base of *Acer buergerianum*, 13 April 2022). Fukiage: YO13982 (on bark of *Acer palmatum*, 10 December 2021).

91. ***Micarea byssacea*** (Th. Fr.) Czarnota *et al*.

This is a sterile *Micarea* lacking both apothecia and pycnidia, corresponding to "*Micarea* sp." referred to in Ohmura *et al.* (2014). This specimens was identified in Coppins *et al*. (2021).

Not confirmed during 2021–2025 survey.

92. **Micarea* sp. 1

(Fig. 5F)

This is a fertile, apotheciate individual. According to our preliminary phylogenetic analysis based on mitochondrial small-subunit sequences (data not shown), it appears to be closely related to the clade containing *M. pumila* Kantelinen & Myllys and *M. versicolor* Kantelinen, Hyvärinen & Myllys (see Kantelinen *et al.* 2021).

Specimen examined. Momijiyama: MS1121 (on trunk base of *Pinus densiflora*, 17 January 2023).

93. **Myelochroa aurulenta* (Tuck.) Elix & Hale

(Fig. 5G)

Specimens examined. Inui: YO14706 (on trunk of *Cerasus* × *yedoensis*, 30 April 2025). Kitanomaru: YO14271 (on bark of *Cerasus serrulata*, 6 June 2023), YO14293 (on bark of *Cerasus* sp., 6 June 2023). Nakadokan: MS1073 (on stone wall, 20 May 2022).

94. ***Normandina pulchella*** (Borrer) Nyl.

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

95. ***Opegrapha*** sp. 1

(Fig. 5H–I)

This corticolous species is characterized by a brownish olive-grey, largely endosubstratal thallus; black, triangular to short lirellate ascomata, 0.4–0.7 × 0.2–0.3 mm; persistently I+ blue hypothecium; and hyaline, fusiform-acicular, 3–5-septate ascospores (22–31 × 4.5–6 µm) with an epispore forming auricles at the ends. For a detailed description, see Ohmura *et al.* (2014).

Specimens examined. Hakucho: YO14235 (on bark of *Acer palmatum*, 6 December 2022). Inui: MS972 (on bark of *Acer palmatum*, 10 December 2021). Kanbaku: MS995 (on bark of *Acer palmatum*, 10 December 2021). Tomodamari: MS1126 (on bark of *Ternstroemia gymnanthera*, 7 February 2023).

96. ***Opegrapha*** sp. 2

This species is characterized by a pale fawn thallus with patches of pale orange; black, lirellate ascomata up to 1 × 0.1–0.2 mm; I+ pale orange-red hymenium; and fusiform-acicular, 3–5-septate ascospores (25–30 × 4 µm) with a c. 1 µm wide epispore. The pycnidia are conical and black (0.1–0.2 mm in diam.), producing curved to weakly sigmoid conidia 5–8(–12) × 1–1.5

μm. For a detailed description, see Ohmura *et al.* (2014).

Not confirmed during 2021–2025 survey.

97. ***Opegrapha*** sp. 3

(Fig. 5J–K)

This species is distinguished from other *Opegrapha* spp. in this area by its lirellate apothecia (up to 0.5 × 0.1 mm), the uppermost 15 μm of the hymenium being persistently I+ blue, and the 6–8-septate ascospores (21–26 × 3–5 μm excluding the epispore) (Ohmura *et al.*, 2014).

Specimens examined. Chikurin: MS1040 (on bark of *Acer buergerianum*, 13 April 2022). Fukiage: YO9586 (on bark of *Acer buergerianum*, 7 March 2013). Hakucho: MS1027 (on bark of *Acer buergerianum*, 10 March 2022).

98. ***Opegrapha*** sp. 4

This species is characterized by a whitish, weakly glossy thallus up to 0.05 mm thick; the absence of ascomata; and strongly emergent, hemispherical to conical pycnidia covered with thick whitish pruina and containing orange pigment in the apical parts. The pycnidia measure 0.2–0.4 mm in diameter and 0.2–0.3 mm in height, and produce bacilliform, often weakly curved conidia (6–9 × 1.5–2.2 μm) (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

99. ***Parmotrema austrosinense*** (Zahlbr.) Hale

Specimens examined. Hisago: YO14347 (on bark of *Cedrus deodara*, 7 February 2023). Inui: MS962 (on bark of *Pinus thunbergii*, 29 September 2021), YO13946 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO14384 (on trunk of *Pinus thunbergii*, 27 February 2024). Kitanomaru: YO14282 (on bark of *Cerasus serrulata*, 6 June 2023). Nakadokan: YO14134 (on stone wall, 20 May 2022).

100. ***Parmotrema clavuliferum*** (Räsänen) Streimann

Specimens examined. Dokan-Shin: YO14755 (on branch of *Quercus acutissima*, 12 June 2025, coll.: J. Kosugi). Inui: YO13954 (on bark of *Prunus lannesiana* 'Sekiyama', 29 September 2021). YO13972 (on stone wall, 29 September 2021), YO14700 (on trunk of *Cerasus* × *yedoensis*, 30 April 2025). Kitanomaru: YO14270, YO14281 (on bark of *Cerasus serrulata*, 6 June 2023), YO14292 (on bark of *Cerasus* sp., 6 June 2023). Ohmichi: YO14358 (on trunk of *Cerasus* sp., 27 June 2023).

101. ***Parmotrema tinctorum*** (Despr. ex Nyl.) Hale

(Fig. 7G)

Specimens examined. Fukiage: YO9879 (on bark of *Prunus* sp., 18 July 2013). Inui: MS956 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), MS976 (on stone wall, 29 September 2021), YO13956 (on bark of *Prunus lannesiana* 'Sekiyama', 29 September 2021), YO14374 (on trunk of *Cerasus* sp., 27 February 2024). Kashiko: MS1039 (on trunk of *Cerasus* × *yedoensis*, 13 April 2022). Nakadokan: YO14128 (on stone wall, 20 May 2022). Kitanomaru: YO14269, YO14279 (on bark of *Cerasus serrulata*, 6 June 2023). Ohmichi: YO14359 (on trunk of *Cerasus* sp., 27 June 2023).

102. ***Pertusaria flavicans*** Lamy

Specimen examined. Hanzo: YO14063 (on stone wall, 13 April 2022).

103. ***Pertusaria pertusa*** (L.) Tuck.

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

104. ****Pertusaria pustulata*** (Ach.) Duby

(Fig. 5L)

Specimens examined. Dokan-Shin: YO14006 (on bark of *Cerasus* × *yedoensis*, 10 December 2021). Inui: YO6826 (on bark of *Cerasus* × *yedoensis*, 3 December 2009).

105. ***Pertusaria*** sp.

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

106. ***Phaeographis pruinosa*** M. Nakan.

See Ohmura *et al.* (2022). Not confirmed during 2021–2025 survey.

107. ***Phaeophyscia limbata*** (Poelt) Kashiw.

See Ohmura *et al.* (2022).

Specimens examined. Hakucho: MS1026, YO14030 (on bark of *Acer palmatum*, 10 March 2022). Inui: MS957 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO13962 (on bark of *Acer buergerianum*, 29 September 2021), YO13967 (on concrete, 29 September 2021), YO14701 (on trunk of *Cerasus itosakura*, 30 April 2025). Kitanomaru: YO14273 (on bark of *Cerasus serrulata*, 6 June 2023), YO14278 (on bark of *Podocarpus macrophyllus*, 6 June 2023), YO14299 (on bark of *Cinnamomum camphora*, 6 June 2023). Nakadokan: MS1082 (on stone wall, 20 May 2022). Oike: YO14010 (on bark of *Zelkova serrata*, 10 December 2021).

108. ***Phaeophyscia rubropulchra*** (Degel.) Moberg

Specimens examined. Hanzo: MS1055 (on stone wall, 13 April 2022). Inui: MS958, MS960 (on trunk base of *Cerasus* × *yedoensis*, 29 September 2021). Kitanomaru: YO14272 (on bark of *Cerasus serrulata*, 6 June 2023), YO14287, YO14298 (on bark of *Zelkova serrata*, 6 June 2023). Nakadokan: MS1074, YO14142 (on stone wall, 20 May 2022). Oike: MS1008, MS1009 (on rock, 10 December 2021).

109. **Phaeophyscia spinellosa* Kashiw. (Fig. 6A)

Specimens examined. Inui: YO13964 (on concrete, 29 September 2021). Kyuden: YO14330 (on rock, 17 January 2023).

110. ***Physciella melanchra*** (Hue) Essl.

Specimens examined. Fukiage: MS992 (on bark of broadleaf deciduous tree, 10 December 2021). Hakucho: MS1031 (on rock, 10 March 2022). Hanzo: YO14073 (on stone wall, 13 April 2022). Inui: YO13966 (on concrete, 29 September 2021).

111. ***Placynthiella icmalea*** (Ach.) Coppins & P. James

Specimen examined. Inui: YO13950 (on trunk base of *Cerasus* × *yedoensis*, 29 September 2021).

112. ***Polyblastia*** sp.

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

113. ***Porina hirsuta*** Aptroot & K.H. Moon

Specimens examined. Fukiage: MS988 (on bark of *Acer palmatum*, 10 December 2021). Hakucho: YO14026 (on rock, 10 March 2022), MS1029, YO14029 (on bark of *Acer palmatum*, 10 March 2022). Inui: MS973 (on bark of *Acer palmatum*, 29 September 2021). Kain-tei: YO14041 (on rock, 10 March 2022). Kamidokan: MS1069 (on trunk base of *Camellia japonica*, 20 May 2022), YO14127 (on trunk base of *Zelkova serrata*, 20 May 2022). Kanbaku: MS994 (on bark of *Acer palmatum*, 10 December 2021), MS996 (on rock, 10 December 2021), MS1097 (on bark of *Cercidiphyllum japonicum*, 6 December 2022), MS1098, MS1101 (on rock, 6 December 2022). Momijiyama: MS1119 (on trunk base of *Pinus densiflora*, 17 January 2023). Nakadokan: MS1083 (on rock, 20 May 2022). Oike: MS1017, YO14000 (on rock, 10 December 2021).

114. ***Porina leptalea*** (Durieu & Mont.) A.L. Sm.

Specimens examined. Fukiage: MS989 (on bark of *Acer palmatum*, 10 December 2021). Inui: MS980 (on stone wall, 29 September 2021). Sakashita: MS1110 (on fragment of roof tile, 17 January 2023).

115. ***Porina*** sp. 1

This species is characterized by a greenish brown, gelatinous and cracked thallus; small hemispherical to conical perithecia (up to 0.1 mm in diam.) with a blackish involucrellum lacking purple-violet pigmentation; and 3-septate ascospores (22–23 × 5 μm) (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

116. ***Porina*** sp. 2

This species is characterized by a thin, smooth, greenish brown thallus; black, hemispherical, hairless perithecia (up to 0.2 mm in diam.) with a blackish involucrellum lacking purple-violet pigmentation; and

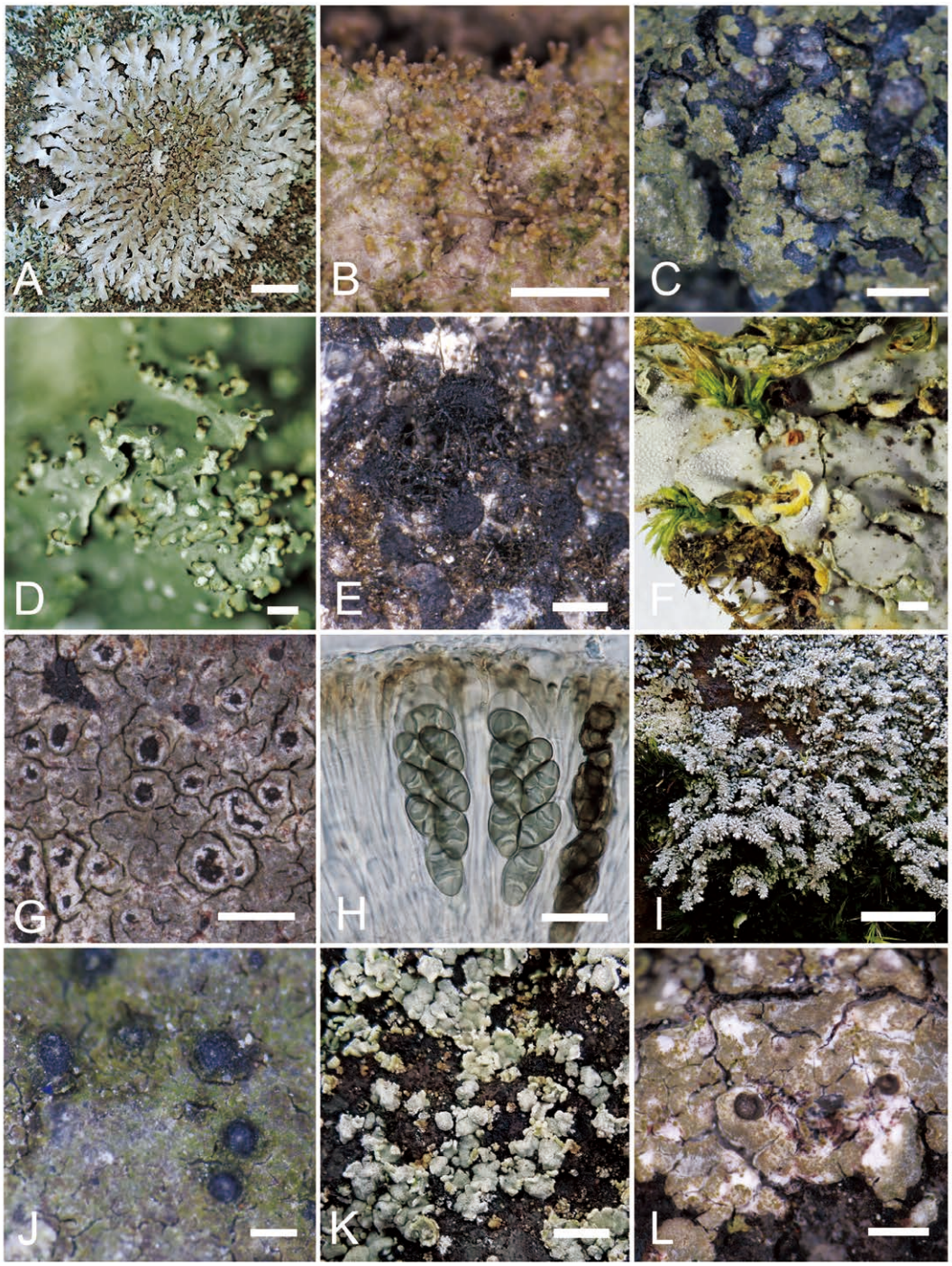

Fig. 6. Selected images of lichens from the Imperial Palace Grounds. A. *Phaeophyscia spinellosa* (YO14330). B. *Porina* sp. 4 (YO14001). C. *Psoroglaena humidosilvae* (GT29654). D. *Punctelia ruderata* (MS1021). E. *Pyrenopsis* sp. (YO14335). F. *Pyxine sorediata* (YO14132). G. *Rinodina oxydata* (YO14331). H. Ascospores of *Rinodina oxydata* (YO14331). I. *Stereocaulon* sp. (MS1124). J. *Thelidium rehmii* (MS1071). K. *Trapelia pruinosa* (YO14326). L. *Trapelia terrestris* (MS1048). Scales: A, I = 5 mm. B–G, L = 0.5 mm. H = 20 μm. J = 200 μm. K = 1 mm.

7–8-septate ascospores (40–41 × 3 μm) (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

117. ***Porina*** sp. 3

See Kashiwadani and Thor (2000) and Ohmura *et al.* (2014). This species resembles *Enterographa zonata* (Körb.) Källsten ex Torrente & Egea and some *Opegrapha* species but is distinguished by the absence of prothallus, the gelatinous thallus and the absence of secondary substances.

Specimen examined. Nakadokan: MS1075 (on stone wall, 20 May 2022).

118. **Porina*** sp. 4

(Fig. 6B)

This species belongs to the group of isidiate *Porina* species, such as *Porina coralloidea* P. James. Because only a sterile isidiate thallus lacking both perithecia and conidia is available, its taxonomic position is difficult to clarify and requires careful evaluation using DNA data.

Specimen examined. Oike: YO14001 (on rock, 10 December 2021).

119. ***Porpidia albocaerulescens*** (Wulfen) Hertel & Knoph

Specimens examined. Inui: YO13973 (on stone wall, 29 September 2021). Kanbaku: MS1000 (on rock, 10 December 2021), MS1099 (on rock, 6 December 2022). Kyuden: YO14333 (on rock, 17 January 2023). Nakadokan: YO14129 (on stone wall, 20 May 2022). Oike: MS1018 (on rock, 10 December 2021).

120. *+Psoroglaena humidosilvae*** B.G. Lee

Japanese common name newly proposed: *Uroko-mukimi-goke*

(Fig. 6C)

This species corresponds to "Lichen sp. 2" in Ohmura *et al.* (2014). This species was characterized by an appressed, vivid green squamulose thallus without ascomata or pycnidia (Ohmura *et al.*, 2014). Although the specimen from the Imperial Palace Grounds is sterile, the ITS sequence of GT29654 shows high similarity (100%) with those of this species (OM811988, Lee and Hur, 2022) and the additional fertile specimen collected from another locality of Tokyo (Y. Ohmura 11246, TNS).

Not confirmed during 2021–2025 survey.

Specimen examined. Kashiko: GT29654 (on old asphalt, 8 March 2013).

Additional specimen examined. JAPAN. Honshu. Musashi Prov. (Tokyo Metropolis): Institute for Nature Study, National Museum of Nature and Science, Shirokanedai, Minato-ku (35°38′14″N, 139°43′04″E), on stone wall, elevation 5 m, 28 March 2017, Y. Ohmura 11246 (TNS).

121. ***Punctelia borreri*** (Sm.) Krog

Specimens examined. Inui: MS952 (on bark of *Cerasus* × *yedoensis*, 29 September 2021), YO14370 (on trunk of *Cerasus itosakura*, 27 February, 2024). Kitanomaru: YO14288 (on bark of *Cerasus* sp., 6 June 2023). Nakadokan: YO14135 (on stone wall, 20 May 2022).

122. **Punctelia ruderata*** (Vain.) Canêz & Marcelli

(Fig. 6D)

Alors *et al.* (2016) conducted a phylogenetic analysis of *Punctelia rudecta* s. lat., which included four Japanese specimens from Ibaraki and Saitama Prefectures, central Honshu. Their results showed that these Japanese specimens did not belong to the clade of *P. rudecta* s. str. but formed a separate clade, which they identified as *P. ruderata*. A preliminary analysis of *P. rudecta* s. lat. from an additional four localities in central Honshu (Gunma, Ibaraki, Shizuoka, and Shiga) conducted by the present author similarly detected no specimens belonging to the clade of *P. rudecta* (Ach.) Krog s. str., and all examined samples fell within *P. ruderata* (data not shown). Whether *P. rudecta* s. str. actually occurs in Japan will require further detailed investigation. Although the ITS sequence could not be obtained from the samples from the Imperial Palace Grounds, they are identified here

as *P. ruderata* in light of the preliminary analyses described above.

Specimen examined. Agency: MS1021 (on bark of *Zelkova serrata*, 10 December 2021).

123. ***Pyrenopsis*** sp.

(Fig. 6E)

For a detailed description, see Kashiwadani and Thor (2000). The taxonomy of Japanese *Pyrenopsis* species has not been sufficiently studied, and reliable identification at the species level is difficult at present.

Specimens examined. Agency: YO14335 (on concrete, 17 January 2023). Sankaku: YO14345 (on concrete, 7 February 2023).

124. ***Pyrenula fetivica*** (Kremp.) Müll. Arg.

(Fig. 7J, K)

It was collected in Kitanomaru Park, not found in the Imperial Palace Grounds.

Specimen examined. Kitanomaru: YO14303 (on bark of *Carpinus* sp., 6 June 2023).

125. ***Pyrenula*** sp.

This species is characterized by a greenish, crustose thallus with UV-; solitary ascomata with apical ostioles; an unbranched and non-inspersed hamathecium; and brown, 3-septate ascospores with angular lumina (17.5–25.1 × 7.5–8.4 µm) (Ohmura *et al.*, 2014).

Not confirmed during 2021–2025 survey.

126. [*] ***Pyxine sorediata*** (Ach.) Mont.

(Fig. 6F)

A small poorly developed individual was found.

Specimen examined. Nakadokan: YO14132 (on stone wall, 20 May 2022).

127. ***Ramonia luteola*** Vězda

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

128. ***Remototrachyna incognita*** (Kurok.) Divakar & A. Crespo

(Fig. 7L)

It was collected in Kitanomaru Park, not found in the Imperial Palace Grounds.

Specimen examined. Kitanomaru: YO14274 (on bark of *Cerasus serrulata*, 6 June 2023).

129. [*] ***Rinodina oxydata*** (A. Massal.) A. Massal.

(Fig. 6G, H)

Specimens examined. Fujimi-HG: YO14340 (on stone wall, 7 February 2023). Kyuden: YO14331 (on rock, 17 January 2023).

130. [†] ***Scoliciosporum chlorococcum*** (Graewe ex Stenh.) Vězda

The corticolous "*S. umbrinum*" reported in Ohmura *et al.* (2014) corresponds to this species.

Specimens examined. Honmaru: YO7696 (on bark of *Prunus lannesiana*, 14 October 2010). Inui: YO9562 (on bark of *Cerasus* × *yedoensis*, 6 March 2013). Kanko: YO14034 (on branch of *Prunus* sp., 10 March 2022). Ohmichi: MS1108, YO14247 (on twig of *Cerasus itosakura*, 6 December 2022).

131. ***Scoliciosporum umbrinum*** (Ach.) Arnold

Because no saxicolous specimens were collected, this species was not confirmed during either the 2009–2013 or the 2021–2025 survey periods.

132. ***Sculptolumina japonica*** (Tuck.) Marbach

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

133. [+] ***Squamulea loekoesiana*** (S.Y. Kondr. & Upreti) Arup, Søchting & Bungartz

Japanese common name: *Kouroko-daidai-goke* (Ohmura, 2016).

The BLAST result for the ITS sequence of specimens shows the high similarity with 99.42–100% to *Squamulea loekoesiana* from South Korea (GenBank KY614406, KY614407; Kondratyuk *et al.*, 2017).

The Japanese taxon had previously been referred to as *Squamulea* aff. *subsoluta* (Ohmura, 2016) or *Squamulea* cf. *subsoluta* (Ohmura and Sugimoto, 2019). Although ITS sequences of the taxon indicated that it corresponds to *S. loekoesiana*, the morphological features between the two species sometimes overlap, making it difficult to distinguish them clearly. For this reason, the first author continued to use the name "*Squamulea* cf. *subsoluta*" to avoid sep-

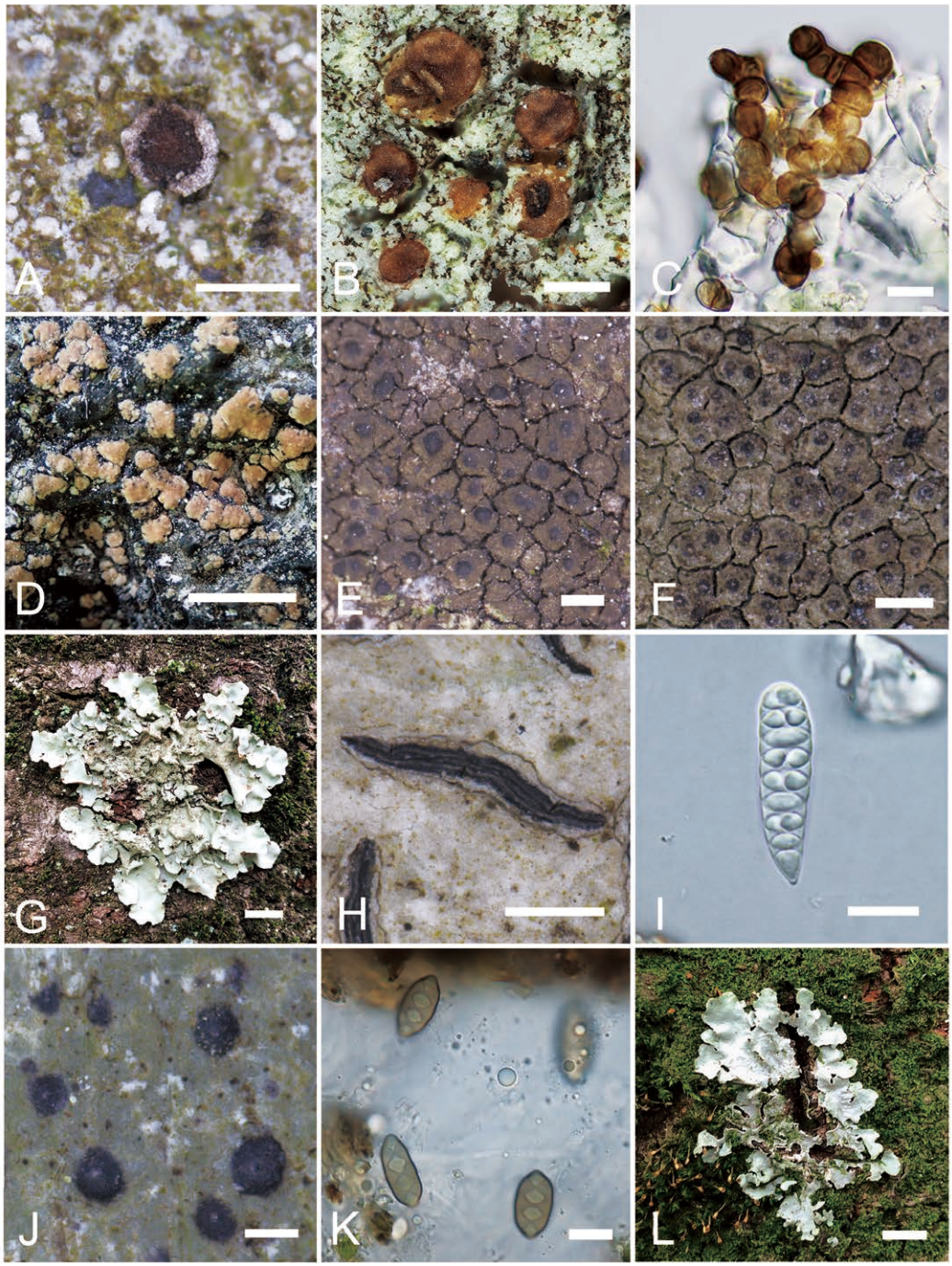

Fig. 7. Selected images of lichens from the Imperial Palace Grounds (A–F) and Kitanomaru Park (G–L). A. *Trapelia* sp. (YO14324). B. Ascomata of *Trimmatostroma* sp. on the thallus of *Lecidella* sp. (YO8440 pr.p.). C. Conidiogenous cells and conidia of *Trimmatostroma* sp. (YO8440 pr.p.). D. *Trimmatothelopsis* sp. (MS1044). E. *Verrucaria* sp. 1 (YO14060). F. *Verrucaria* sp. 2 (MS1001). G. *Parmotrema tinctorum* (YO14279). H. *Graphis deserpens* (YO14304). I. Ascospore of *Graphis deserpens* (YO14304). J. *Pyrenula fetivica* (YO14303). K. Ascospores of *Pyrenula fetivica* (YO14303). L. *Remototrachyna incognita* (YO14274). Scales: A, E, F, H, J = 0.5 mm. B = 200 µm. C, I, K = 10 µm. D, L = 5 mm. G = 1 cm.

arating them solely on the basis of DNA data. However, since *S. loekoesiana* and *S. subsoluta* have been shown not to form a sister group nor belong to the same clade (Bungartz *et al.*, 2020), it is appropriate to apply the name *S. loekoesiana* to the Japanese taxon instead of "*Squamulea* cf. *subsoluta*". Thus, *Squamulea loekoesiana* is reported here for the first time from Japan under the currently accepted name.

Specimens examined. Hanzo: YO7674 (on stone wall, 13 October 2010), MS1051, YO14059 (on stone wall, 13 April 2022). Inui: MS986 (on concrete, 29 September 2021). Ohmichi: YO14241 (on rock, 6 December 2022). Oike: MS1013 (on rock, 10 December 2021).

134. **Stereocaulon* sp.

(Fig. 6I)

This species resembles *Stereocaulon japonicum* Th. Fr. and *S. verruciferum* Nyl. While *S. japonicum* contains stictic acid but lacks lobaric acid and *S. verruciferum* contains lobaric acid but lacks stictic acid, the present specimen contains both substances. The taxonomic position of this taxon remains uncertain and needs further molecular phylogenetic study.

Sakashita: MS1124 (on stone wall with mosses, 17 January 2023).

135. ***Strangospora*** sp.

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

136. ***Strigula*** sp.

This is a saxicolous species. See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

137. ***Thelidium japonicum*** H. Harada

See Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

138. **Thelidium rehmii* Zschacke

(Fig. 6J)

Specimen examined. Kamidokan: MS1071 (on rock, 20 May 2022).

139. ***Trapelia coarctata*** (Turner) M. Choisy

Specimens examined. Oike: MS1010, MS1012 (on rock, 10 December 2021).

140. ***Trapelia placodioides*** Coppins & P. James

Specimens examined. Inui: MS984 (on rock, 29 September 2021). Kikyo: MS1130 (on rock, 7 February 2023). Oike: YO13997 (on rock, 10 December 2021).

141. *+Trapelia pruinosa* Elix & P.M. McCarthy

Japanese common name newly proposed: *Hakufun-bara-goke*.

(Fig. 6K)

This species is characterized by the esorediate, squamulose thallus with pruina on the surface (Elix and McCarthy, 2020a). The ITS sequence also shows high similarity with those of this species (e.g., 98.76%, OM955179).

Specimen examined. Shoko-mon: YO14326 (on rock, 17 January 2023).

142. *+Trapelia terrestris* Elix & P.M. McCarthy

Japanese common name newly proposed: *Chami-bara-goke*.

(Fig. 6L)

According to Elix and McCarthy (2020b), this species resembles *Trapelia coarctata* but differs in having sessile apothecia with rough, coarsely granular discs and somewhat larger ascospores, 14–30 × 8–15 μm. Although the Japanese material has poorly developed apothecia and no ascospores were observed, the ITS sequences show more than 98% similarity with *T. terrestris*, and a preliminary phylogenetic analysis indicates a close relationship with OM955187 (voucher: McCarthy 4898, CANB, not seen).

However, ITS data do not clearly separate this species from *T. atrocarpa* Elix & P.M. McCarthy. *Trapelia terrestris* differs from *T. atrocarpa* in having apothecia lacking a white thalline rim, a micro-areolate thallus, and no calcium oxalate in the medulla, whereas *T. atrocarpa* has apothecia surrounded by a well-developed white thalline rim and contains calcium oxalate. Further taxonomic research is needed to clarify the relationship between these species.

Specimens examined. Inui: MS982 (on rock, 29 September 2021), YO13970 (on stone wall, 29 September 2021). Hanzo: MS1048 (on stone wall, 13 April 2022).

143. [*] ***Trapelia*** sp.

(Fig. 7A)

This species has a very thin, diffuse, discontinuous thallus with white tubercles, and possibly being an undescribed species. Further taxonomic research is needed.

Specimens examined. Sakashita: MS1109, YO14324 (on fragment of roof tile, 17 January 2023).

144. [§] ***Trimmatostroma*** sp.

(Fig. 7B, C)

This is a lichenicolous fungus characterized by black colonies on the host thallus and the shape of conidia (aseptate to 1-transverse septate, roughened surface). Although this species is known to parasitize species of *Lecanora* (Diederich *et al.*, 2024), the current material was found on the thallus of *Lecidella* sp. growing on bark of *Cercidiphyllum japonicum*. Because the host belongs to a different genus, the identification is kept at the genus level in this study.

Specimen examined. Inui: YO8440 pr.p. (on *Lecidella* sp. on bark of *Cercidiphyllum japonicum*, 1 December 2011).

145. ***Trimmatothelopsis*** sp.

(Fig. 7D)

"*Acarospora* sp." in Ohmura *et al.* (2014). The BLAST result for the sequence of specimen YO9598 shows 97.38% similarity to *Trimmatothelopsis anthracina* J.X. Wang & L. Hu from China (GenBank PV541752; Wang *et al.*, 2025).

Specimens examined. Hanzo: MS1044, MS1045 (on stone wall, 13 April 2022). Nakadokan: MS1076 (on stone wall, 20 May 2022). Sankaku: YO9598 (on stone wall, 8 March 2013).

146. ***Verrucaria*** sp. 1

(Fig. 7E)

This species is characterized by the cracked, greenish gray to blackish brown thallus, including "*Verrucaria* sp. 1" in Kashiwadani and Thor (2000) and "*Verrucaria* sp. 3" in Ohmura *et al.* (2014).

Specimens examined. Dokan-Shin: YO14007 (on mortar, 10 December 2021). Hanzo: YO7666 (on rock, 13 October 2010), MS1047, YO14060 (on stone wall, 13 April 2022). Inui: YO8438 (on concrete, 1 December 2011), YO13968 (on mortar, 29 September 2021). Kanbaku: YO13992 (on rock, 10 December 2021). Kyuden: MS1123 (on rock, 17 January 2023). Ohmichi: YO14244 (on rock, 6 December 2022). Oike: YO13996 (on rock, 10 December 2021). Sakashita: MS1114 (on concrete, 17 January 2023), YO14322, YO14323 (on fragment of roof tile, 17 January 2023). Sakurada: YO9592 (on concrete, 7 March 2013). Sankaku: MS1136 (on concrete, 7 February 2023).

147. ***Verrucaria*** sp. 2

(Fig. 7F)

This species is characterized by the cracked, whitish grey thallus. For a detailed description, see Kashiwadani and Thor (2000).

Specimens examined. Fukiage: YO6816 (on rock, 26 October 2009), YO9582 (on rock, 7 March 2013). Hakucho: MS1093 (on rock, 6 December 2022). Kanbaku: MS1001 (on rock, 10 December 2021).

148. ***Verrucaria*** sp. 4

For a detailed description (to avoid confusion, "*Verrucaria* sp. 4" is retained here), see Ohmura *et al.* (2014). Not confirmed during 2021–2025 survey.

Specimen examined. Fukiage: YO9579 (on concrete, 7 March 2013).

Comparison of lichen biodiversity from the First Period (1995–1996) to the Third Period (2021–2025)

The lichen diversity in the Imperial Palace Grounds has increased markedly over the past three decades. Species richness rose from 57 taxa

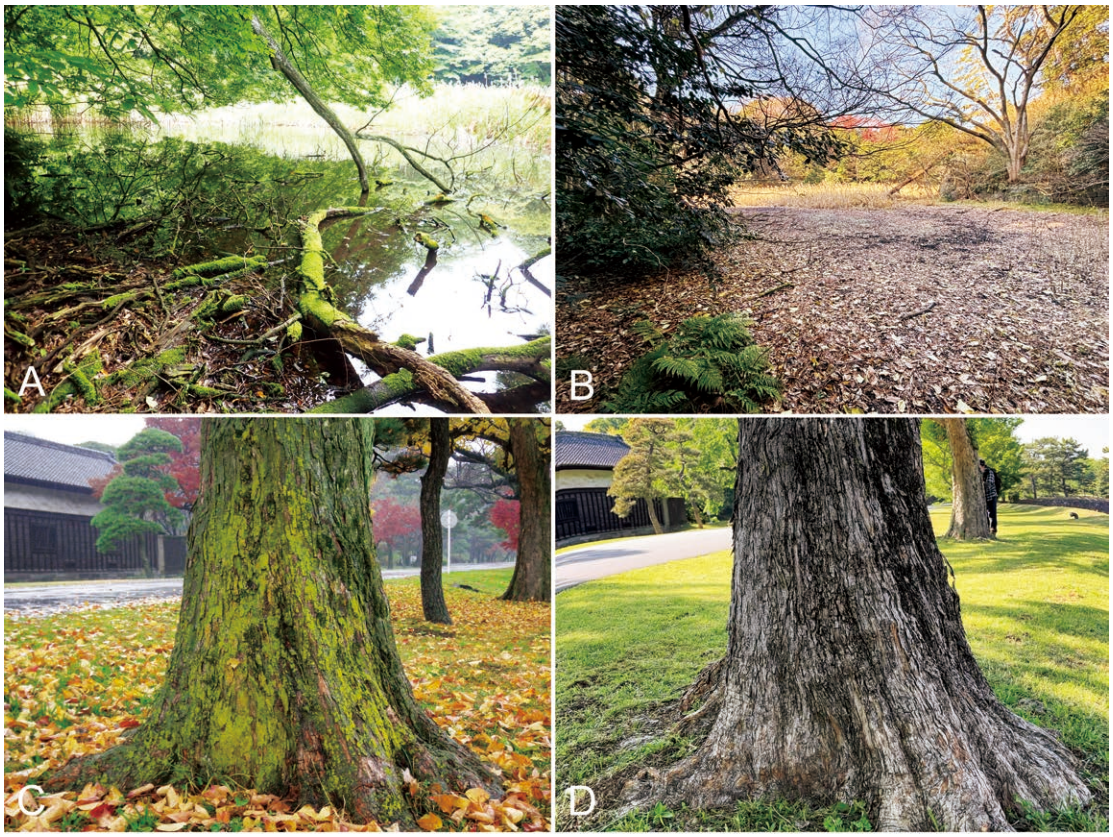

Fig. 8. Local disappearance of lichens within the Imperial Palace Grounds. A. A stagnant water area along the Kami-Dokan Moat, representing a long-term humid microhabitat that supported foliicolous lichens at least until 20 May 2022. B. The same moat basin after drying by 25 December 2025, indicating the loss of persistent humid conditions; no foliicolous lichens were observed there. C. A well-developed population of *Candelaria asiatica* growing on the trunk of *Acer buergerianum*, recorded on 3 December 2009. D. The same trunk photographed on 30 April 2025, showing the near-complete disappearance of *C. asiatica*.

in 1995–1996 to 98 taxa in 2009–2013 and reached 110 taxa in 2021–2025, resulting in a cumulative total of 145 taxa. This increase reflects the remarkable improvement of air quality in Tokyo following the enforcement of strict diesel exhaust regulations in 2003 (see Ohmura *et al.*, 2012), the sustained clean atmospheric conditions since then, and advances in taxonomic resolution enabled by molecular data.

In the 2021–2025 survey, eight species newly reported from Japan and 35 species newly recorded from the Imperial Palace Grounds were identified. These results reflect the significant improvement in identification confidence due to the recent expansion of DNA reference data in GenBank. Likewise, several taxa previously recorded only as "sp." or under provisional names were reassigned to known species or genera, and the category "Lichen sp.", formerly used for taxa with uncertain generic placement, no longer appears in the present list.

Thirty-five taxa recorded in earlier surveys were not confirmed in the latest inventory of the Imperial Palace Grounds. Most of these were small and easily overlooked, and were represented by single or rare occurrences, which makes them more likely to be affected by subtle microhabitat changes, the removal or aging of substrates, or small population sizes rather than true disappearance. However, the exact reasons for the absence of these records re-

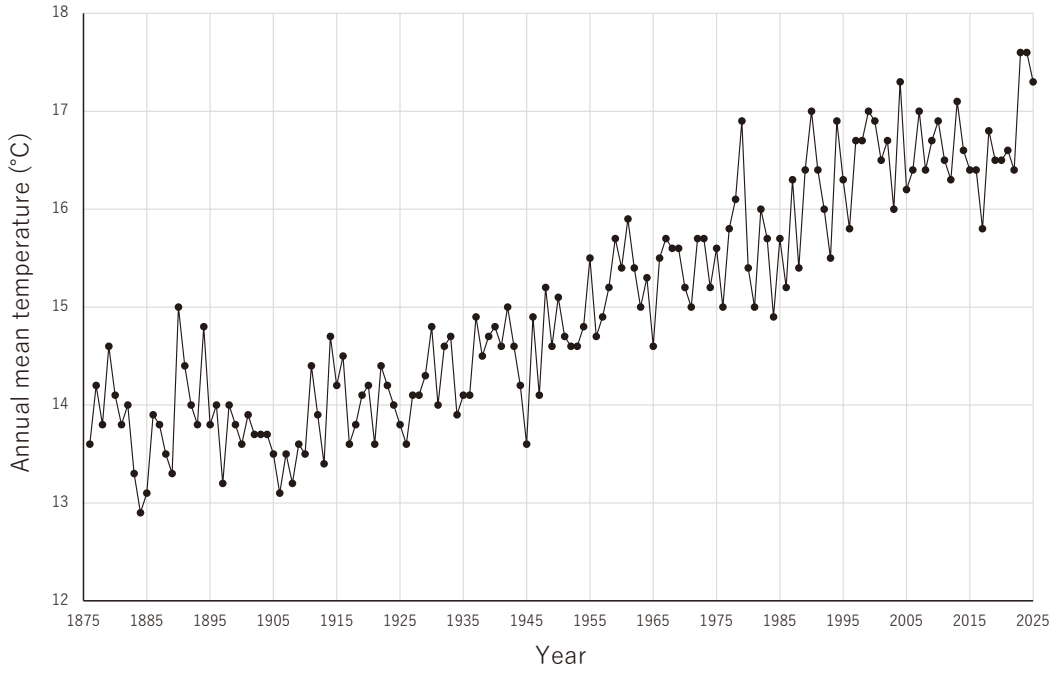

Fig. 9. Annual mean temperature (°C) at the Tokyo Meteorological Station, 1875–2025 (Data source: Japan Meteorological Agency).

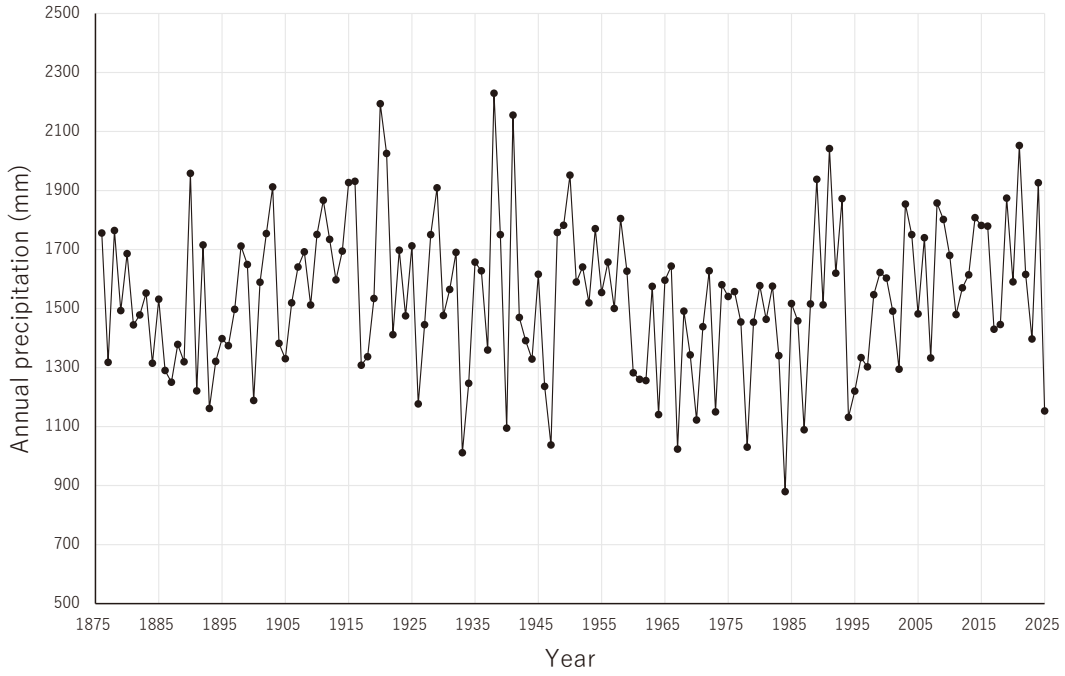

Fig. 10. Annual precipitation (mm) at the Tokyo Meteorological Station, 1875–2025 (Data source: Japan Meteorological Agency).

main uncertain.

Compared with another locality in central Tokyo, the Institute for Nature Study (35°38′N, 139°43′E, 5–30 m elev.) which comprises 46 taxa (Ohmura and Sugimoto, 2019), the Imperial Palace Grounds exhibit considerably higher lichen diversity (145 taxa). This richness likely reflects the wide range of habitats within the area, including a forest developed largely under natural processes, the historic stone walls of the former Edo Castle, small streams and wetlands within the forest interior, and the surrounding moats. These diverse environments are considered to support and maintain high lichen diversity. Notably, the finding of the foliicolous lichen, *Bacidina apiahica*, suggests that the long-term persistence of humid microhabitats, consistent with little anthropogenic disturbance at the site (see Lücking 1997, 2008). Although this species was confirmed in 2022, no foliicolous lichens were observed on living leaves during a field survey conducted in December 2025, probably due to the loss of humid conditions following the drying up of the moat (Fig. 8A, B). In addition, a remarkable decline of the *Candelaria asiatica* population on the trunk of *Acer buergerianum* was documented from 3 December 2009 to 30 April 2025 (Fig. 8C, D). In urban environments, bleaching and subsequent mortality of lichens have been reported, and these phenomena have been suspected to be associated with recent increases in temperature and reduced precipitation (Ohmura *et al.*, 2023). During the first (1995–1996) to the second survey (2009–2013) of lichens in the Imperial Palace Grounds, a dramatic recovery of lichen diversity was observed, which was attributed to improvements in air quality (Ohmura *et al.*, 2012, 2014). However, during the latter half of the third survey period (i.e., 2023–2025), annual mean temperatures reached 17.3–17.6 °C (among the highest values in the long-term record, Fig. 9), and precipitation was reduced (1152.5 mm in 2025, Fig. 10) at the Tokyo Meteorological Station adjacent to the Imperial Palace Grounds, which may be influencing lichen populations. The impacts of these climatic factors on lichen diversity will be assessed in the next comprehensive survey.

A preliminary survey of Kitanomaru Park suggested that the area provides relatively favorable conditions for lichens, as evidenced by the occurrence of foliose macrolichens, such as *Parmotrema tinctorum* (Fig. 7G), a species often regarded as sensitive to air pollution. In addition, three species, *Graphis deserpens* (Fig. 7H, I), *Pyrenula fetivica* (Fig. 7J, K), and *Remototrachyna incognita* (Fig. 7L), were found in the park but remain unconfirmed within the Imperial Palace Grounds. Their absence, despite intensive surveying in the Imperial Palace Grounds, suggests subtle but meaningful environmental differences between the two green spaces.

Overall, the long-term dataset acquired from 1995 to 2025 demonstrates the value of repeated inventories for understanding biodiversity dynamics in large urban green spaces. Continued monitoring will be essential to detect further ecological shifts, and to resolve the identities of the remaining unidentified taxa, including potentially undescribed species.

Acknowledgments

We thank the staff of the Imperial Household Agency for their kind help during our investigation in the Imperial Palace Grounds, Tokyo, Japan in 2021–2025. This study was conducted as an integrated research project "A study of biota changes in urban environments over the past 150 years—Analysis of specimens collected mainly from the Imperial Palace in central Tokyo" initiated by the National Museum of Nature and Science, Japan.

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皇居生物相第III期調査における地衣類多様性

大村嘉人・田留健介・久保　浄・宮澤研人

皇居生物相調査（第Ⅲ期）において，2021年9月から2025年12月に実施された地衣類のインベントリー調査の結果，地衣類および関連菌類をあわせて110分類群が確認された．これらは66属82種，および属までしか同定できなかった28分類群から構成されており，地衣生菌3分類群（3属）および非地衣化菌1分類群も含まれる．

1995–1996年（第I期）および2009–2013年（第II期）に実施された過去の調査結果を合わせると，当該地域からは累積で145分類群（77属94種1変種，属まで同定された51分類群）が記録され，これには地衣生菌3分類群（3属）および非地衣化菌2分類群（1属）が含まれる．

本研究で確認された分類群のうち，*Lecanora neobarkmaniana*（コフキイワチャシブゴケ，新称），*L. pseudargentata*（ニセヒメチャシブゴケ，新称），*Leprocaulon adhaerens*（ニセロクショウコナチイ，新称），*L. nicholsiae*（ロクショウコナチイ，新称），*Psoroglaena humidosilvae*（ウロコムキミゴケ，新称），*Squamulea loekoesiana*（コウロコダイダイゴケ），*Trapelia pruinosa*（ハクフンバラゴケ，新称），および *T. terrestris*（チャミバラゴケ，新称）は日本新産であり，さらに35分類群が皇居内苑からの新記録である．これらの知見は，第III期で新たに採集された標本および，第II期以前に採集された未同定または曖昧な同定であった既存標本の同定結果に基づいている．

一方，過去の調査で記録されていた35分類群は，第III期調査では確認されなかった．多くは微小で目立たない種であり，現地調査における見落としの可能性が考えられるが，基物の消失や微環境の変化などにより，実際に局所的消失が生じた種も含まれていると推察される．過去の調査において認められた地衣類多様性の回復傾向とは対照的に，本調査期間後半では，一部の地衣類集団の減少や生葉上地衣類の消失が確認された．これらの変化は，近年の気温上昇および降水量の減少と関連している可能性が示唆される．

また，皇居北側に隣接する北の丸公園においても予備的調査を実施し，21種の地衣類を確認した．そのうち *Graphis deserpens*（ホコリモジゴケ），*Pyrenula fetivica*（アオゾメサネゴケ），および *Remototrachyna incognita*（イコマゴケモドキ）の3種は，皇居では詳細な調査を行ったにもかかわらず確認されなかった．

以上，皇居は都市中心部に位置しながら高い地衣類多様性を維持していることが確認された．一方で，近年の環境変動との関連が示唆される種の消長も認められた．本地域における地衣類多様性の長期的変化を評価するためには，継続的なモニタリングが重要である．