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A new record of the Critically Endangered mycoheterotrophic orchid *Neottia furusei* T. Yukawa & Yagame (Orchidaceae) from the northwestern Hidaka Mountains, Hokkaido, Japan

Shoutaro Morita[1], **Yuichiro Shida**[2], **Yusuke Saito**[3], **Kohtaroh Shutoh**[4]

1 Japan Ground Self-Defense Force 7th Division, Infantry Regiment Training Unit, Camp Higashi Chitose, Chitose, Hokkaido, Japan
2 Environmental Insights Laboratory Ltd., Sapporo, Hokkaido, Japan
3 Saito Farm, Eniwa, Hokkaido, Japan
4 The Hokkaido University Museum, Hokkaido University, Sapporo, Hokkaido, Japan

Corresponding author: Yuichiro Shida (shida@env-insights.com)

Abstract. *Neottia furusei* T. Yukawa & Yagame (Orchidaceae) is a critically endangered mycoheterotrophic orchid that is endemic to Japan. We report on a new locality in the northwestern Hidaka Mountains, Hokkaido. This represents the second record in the Hidaka region and the species' westernmost limit in Hokkaido, extending its known range by 65 km north-northwest and 15 km west. We consolidated 16 records in Hokkaido using field surveys, published literature, and biodiversity occurrence databases (GBIF and S-Net). Our findings improve the understanding of the distribution and habitat of this rare orchid, essential for its conservation.

Key words. Conservation, cool-temperate forest, endemic species, species distribution, voucher specimen

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Introduction

The genus *Neottia* Guett. (Orchidaceae) includes both green-leaved, partially mycoheterotrophic, and fully mycoheterotrophic orchid species, as well as fully mycoheterotrophic lineages that evolved from green-leaved ancestors (Yagame et al. 2016; Zhou and Jin 2018; Peng et al. 2022). In Japan, 10 or 11 *Neottia* species have been reported (Yukawa 2015; Inoue et al. 2016). Among these, *Neottia furusei* T. Yukawa & Yagame is a Japanese endemic, fully mycoheterotrophic orchid currently categorized as Critically Endangered by the Japanese Red Data Book (MOEJ Red List 2025).

Neottia furusei exhibits a disjunct distribution between central Honshu and Hokkaido (Yukawa 2015). In Hokkaido, this species has been reported occasionally in the eastern regions, including the Shiretoko Peninsula and Hidaka Mountains (Takita 2001; Uchida and Takita 2007; Asanuma 2011; Sukeno 2011). However, occurrences of this rare orchid are sporadic, and since Sukeno (2011) collected it in 2009, no records have been published from Hokkaido outside the Shiretoko Peninsula for over 14 years.

In August 2023, one of us, S. Morita, discovered an individual with two aboveground shoots resembling those of *N. furusei* during a stream-climbing expedition in the Hidaka Mountains. In August 2024, we revisited the site to confirm the population and to sample voucher specimens. Herein, we report this locality as a new record and update the distribution of *N. furusei* in Hokkaido, Japan.

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Methods

Field sampling and specimen processing. Field surveys were conducted on 4 August 2024, at a locality in Chisaka, Hidaka-cho, Hokkaido, Japan. We searched for individual orchids, counted inflorescences, and recorded the dominant co-occurring vascular plants. Collected plants were pressed and dried using standard herbarium techniques. These voucher specimens were deposited in the Herbarium of the Hokkaido University Museum (SAPS). Identification was performed morphologically based

on published descriptions (Yukawa 2015; Inoue et al. 2016) and by direct comparison with existing herbarium specimens preserved in SAPS.

Coordinates were recorded using a smartphone Global Positioning System (GPS) but are reported only to the nearest minute to prevent the precise localization of the population and reduce the risk of illegal plant collection. Elevation was estimated at approximately 600 m a.s.l. using Google Earth Pro, based on the recorded GPS coordinates.

Specimen collection was authorized by the Hidaka Hokubu Forest Management Office (Hokkaido Forest Management Bureau, Forestry Agency, Japan) under permit 6-Hidaka-Hokubu-Kan-No. 206, issued on 5 July 2024. This permit allowed for the collection of *Neottia furusei* between 15 July and 29 September 2024.

Consolidation of distribution data. We created a distribution map based on integrated records of *N. furusei* in Hokkaido derived from four categories of sources: (1) voucher specimens collected in this study; (2) previous publications (Uchida and Takita 2007; Sukeno 2011); (3) photographs of voucher specimens deposited in the herbarium of the University Archives and Collections, Fukushima University (FKSE), kindly provided by Drs. T. Kurosawa and Y. Yamashita, who recently collected *N. furusei* specimens in Hokkaido; and (4) specimen records from the Global Biodiversity Information Facility (GBIF; Ebihara 2025) and the Science Museum Net (S-Net 2025).

We rigorously verified and standardized all records from categories (1) to (3) and the GBIF data (specifically those from the National Museum of Nature and Science, TNS) by cross-referencing them with the S-Net database. S-Net was instrumental in clarifying ambiguous locality names and verifying coordinates. For instance, several records listed only as "Hokkaido" in the GBIF dataset were standardized to specific municipalities (e.g. "Shari-gun" and "Shari-cho") through this process. After this consolidation and duplicate removal, 16 reliable distribution records were retained for the final analysis and map generation (Table 1).

Table 1. Locality records of *Neottia furusei* in Hokkaido, Japan. Map numbers correspond to those shown in Figure 3. Abbreviations: FKSE, Herbarium, University Archives and Collections, Fukushima University; KIRM, Kitami Region Museum of Science, History and Art; SAPS: The herbarium of the Hokkaido University Museum; TNS, Vascular plant specimens of the National Museum of Nature and Science.

Map no.	Catalog no.	Collection date	Locality	Collector	Repository	Source
1	SAPS 079737; SAPS 079738	4 Aug. 2024	Saru-gun, Hidaka-cho, Chisaka	Kohtaroh Shutoh et al.	SAPS	This study
2	SAPS 033375	2 Oct. 2009	Urakawa-gun, Urakawa-cho, Nobuka	Mikio Sukeno	SAPS	Sukeno 2011
3	s.n.	3 Oct. 1955	Monbetsu, Kamikounomai	Zen-ichi Kawashiro	Shiretoko Forest Ecosystem Conservation Center	Uchida and Takita 2007
4	KIRM 02593	31 Aug. 1981	Tokoro-gun, Kunneppu-cho, Misono	Tsuneo Matsuki	KIRM	Uchida and Takita 2007
5	TNS 8504747	6 Sept. 1997	Kushoro, Onbetsu, Satonbetu	Kenjo Takita	TNS	Uchida and Takita 2007
6	s.n.	17 Sept. 1954	Tokoro-gun, Saroma-cho, Mt. Horoiwa	Toru Misumi	Unknown	Uchida and Takita 2007
7	KIRM 02594; KIRM 02595	7 Sept. 1982	Kitami, Modorigaoka	Tsuneo Matsuki	KIRM	Uchida and Takita 2007
8	FKSE 94278	30 Sept. 2016	Shari-gun, Shari-cho, Onnebetsumura	Yumi Yamashita and Takao Asanuma	FKSE	Kurosawa and Yamashita pers. comm.
9	TNS 8505715	13 Sept. 2014	Shari-gun, Shari-cho	Unknown	TNS	Ebihara 2025
10	TNS 8505232; TNS 8505233	21 Sept. 2013	Shari-gun, Shari-cho	Unknown	TNS	Ebihara 2025
11	TNS 8505711	21 Aug. 2014	Shari-gun, Shari-cho	Unknown	TNS	Ebihara 2025
12	TNS 8505713	29 Aug. 2014	Shari-gun, Shari-cho	Unknown	TNS	Ebihara 2025
13	TNS 8505716	18 Sept. 2014	Shari-gun, Shari-cho	Unknown	TNS	Ebihara 2025
14	FKSE 94277	29 Sept. 2016	Shari-gun, Shari-cho, Onnebetsumura	Yumi Yamashita and Takao Asanuma	FKSE	Kurosawa and Yamashita pers. comm.
15	SAPS 006555	29 Aug. 2000	Shari-gun, Shari-cho, Idasyubetsu River	Akitomo Uchida	SAPS	Uchida and Takita 2007
16	s.n.	29 Sept. 2000	Shari-gun, Shari-cho, Idasyubetsu River	Akitomo Uchida	Shiretoko Museum	Uchida and Takita 2007

*s.n. = sine numero (without a collector's number).

Figure 1. *Neottia furusei* T. Yukawa & Yagame **A.** Habitat. **B.** An individual. **C.** Flower (August 2024). **D.** Flower (August 2023).

The base map for Hokkaido was derived from administrative boundary data provided by the National Land Numerical Information Service (MLIT 2025). A map was then generated using QGIS v. 3.42.

During the preparation of this manuscript, we used Claude (Anthropic), Gemini (Google), and Perplexity for English-language editing to ensure compliance with the journal's formatting requirements. We reviewed and edited the content as needed and take full responsibility for the final version.

Results

***Neottia furusei* T. Yukawa & Yagame**
Figures 1, 2

New record. JAPAN — Hokkaido • Hidaka Mountains, Saru-gun, Hidaka-cho, Chisaka; ca. 42°53′N, 142°34′E (coordinates rounded for conservation); ca. 600 m alt.; 4 Aug. 2024; K. Shutoh et al. leg.; SAPS 079737, SAPS 079738. Figure 3.

Identification. Three individuals, including seven inflorescences, were identified. Their morphology, including non-glandular hairs on the ovary, a three-lobed lip, obliquely ovate lateral sepals, and a greenish plant body, was consistent with the diagnostic characteristics of *N. furusei* reported by Yukawa (2015) and Inoue et al. (2016), and was further confirmed by direct comparison with herbarium specimens preserved in SAPS (SAPS 033375, SAPS 006555).

Habitat. The population was located on a south-southeast-facing slope (ca. 40°). The site was situated in a deciduous, broad-leaved forest. The canopy is dominated by *Quercus crispula* Blume, *Acer pictum* subsp. *mono* (Maxim.) H. Ohashi, *Tilia japonica* (Miq.) Simonk., and *Kalopanax septemlobus* (Thunb.) Koidz. The associated species include *Carpinus cordata* Blume, *Magnolia obovata* Thunb., *Styrax obassia* Siebold & Zucc., and *Abies sachalinensis* (F. Schmidt) Mast. The forest floor is dominated by *Carex pisiformis* Boott and *Pachysandra terminalis* Siebold & Zucc., with other species—such as *Dryopteris crassirhizoma* Nakai, *Adiantum pedatum* L., *Phryma nana* Koidz., *Galium trifloriforme* Kom., *Aconitum sachalinense* subsp. *yezoense* (Nakai) Kadota, *Spuriopimpinella calycina* (Maxim.) Kitag., *Epipactis helleborine* (L.) Crantz, and *Laportea bulbifera* (Siebold & Zucc.) Wedd.—growing sparsely in areas where the topsoil and litter were exposed (Figure 1).

Distribution in Hokkaido. We compiled 16 distribution records of *N. furusei* from Hokkaido (Table 1). Two records, including our new locality in Hidaka-cho, are from the Hidaka region, while the remaining 14 records are from eastern Hokkaido, mainly the Shiretoko Peninsula (Figure 2).

Figure 2. Herbarium voucher of *Neottia furusei* T. Yukawa & Yagame (SAPS 079737), deposited at the Hokkaido University Museum, Hokkaido University, Sapporo, Japan. Collected on 4 August 2024 at the newly recorded locality in Saru-gun, Hidaka-cho, Hokkaido, Japan. Precise locality coordinates are withheld to protect this Critically Endangered species from potential disturbance.

Discussion

The newly discovered locality in the northwestern Hidaka Mountains is approximately 65 km northwest and 15 km west of a previously reported site in Urakawa-cho (Sukeno 2011). This finding represents the second record within the Hidaka region and establishes a new westernmost distribution limit for *Neottia furusei* in Hokkaido. Furthermore, the confirmation of a population in 2024 at the same site where an individual was first sighted in 2023 demonstrates the multiyear persistence of aboveground shoots in this environment. Fully mycoheterotrophic orchids, such as *N. furusei*, do not necessarily produce aboveground shoots every year and may remain entirely belowground for years, making them difficult to detect in the field (Shefferson 2009; Shefferson et al. 2011; Merckx et al. 2012; Suetsugu and Kato 2014). Because of this intermittent appearance, populations are easily overlooked, potentially leading to an underestimation of their actual distribution. Therefore, our findings suggest that *N. furusei* may have a broader potential distribution than previously recognized in the cool-temperate forests of the Hidaka range.

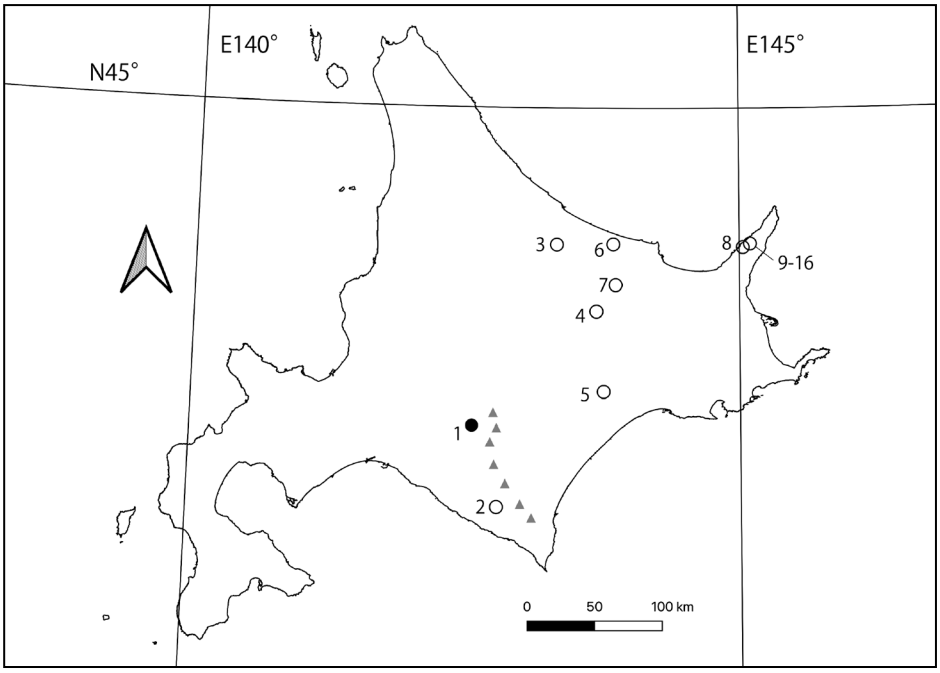

Figure 3. Distribution of *Neottia furusei* in Hokkaido, Japan. **Filled circle:** new locality. **Open circles:** previously known localities. **Grey triangles:** major peaks of the Hidaka Mountains. Map numbers correspond to those listed in Table 1.

We confirmed that the newly identified population occurred on a steep, unstable slope within a deciduous broad-leaved forest with sparse understory vegetation. This closely matches the habitat requirements reported in previous studies conducted across Japan. Common features identified at our site and in the literature include: (1) occurrence in cool-temperate forests dominated by *Q. crispula*, *A. pictum* subsp. *mono*, and *T. japonica* (Imai and Inoue 1998; Sukeno 2011); (2) coexistence with *A. sachalinensis*, either in mixed forests or at the edges of *Abies sachalinensis* plantations (Asanuma 2011; Kurosawa and Yamashita pers. comm.); and (3) a strong preference for sites with minimal competition from other forest floor plants (Imai and Inoue 1998; Asanuma 2011). Given that such steep scree slopes in cool-temperate forests are widely distributed throughout the Hidaka Mountains, our findings suggest that *N. furusei* has a higher potential for occurrence in this region than previously assumed. Further intensive surveys focusing on specific microhabitats—such as steep, shaded, and sparsely vegetated slopes—are required to clarify the full distribution and population status of this Critically Endangered orchid.

The consolidation of these scattered records from Hokkaido (Table 1), including voucher information, is crucial for conserving this Critically Endangered orchid species. Accurate occurrence data are essential for future habitat suitability modelling and the development of effective conservation strategies.

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Additional information

Conflict of interest

The authors declare that no competing interests exist.

Ethical statement

No ethical statement is reported.

Artificial intelligence (AI) use

The authors accept full responsibility for the content of the manuscript, including the disclosure of

any use of AI. Regarding the use of AI in the preparation of this manuscript, the authors declare the following: Claude, Gemini, Perplexity. Used for: language, style, and writing

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Author contributions
Conceptualization YS, KS. Investigation SM (discovered an individual in 2023), SM, YS, Yusuke Saito, KS (field survey in 2024). Identification KS. Data curation YS. Visualization YS. Writing – original draft YS. Writing – review & editing YS, KS.

Author ORCID iDs
Yuichiro Shida https://orcid.org/0009-0009-7715-5864
Kohtaroh Shutoh https://orcid.org/0000-0003-2601-4374

Data availability
All data supporting the findings of this study are available in the main text.

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