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Journal of Threatened Taxa

Open Access

10.11609/jott.2022.14.4.20811-20950
www.threatenedtaxa.org

26 April 2022 (Online & Print)
14(4): 20811–20950
ISSN 0974-7907 (Online)
ISSN 0974-7893 (Print)

ISSN 0974-7907 (Online); ISSN 0974-7893 (Print)

Publisher
Wildlife Information Liaison Development Society
www.wild.zooreach.org

Host
Zoo Outreach Organization
www.zooreach.org

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Cover: ***Saproamanita praeclara*****: Sporocarp in habitat © Kantharaja. R.**

Journal of Threatened Taxa | www.threatenedtaxa.org | 26 April 2022 | 14(4): 20848–20858

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

https://doi.org/10.11609/jott.7485.14.4.20848-20858

#7485 | Received 02 June 2021 | Final received 02 March 2022 | Finally accepted 07 March 2022

COMMUNICATION

Distribution of the genus *Pinguicula* (L., 1753) (Lentibulariaceae) in Gunma Prefecture, Japan with new records

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Abstract: We studied the distribution of two *Pinguicula* (Butterwort) species in Gunma Prefecture, Japan, based on our herbarium specimen examinations and field observations. As a result, several localities of *Pinguicula macroceras*, such as Mt. Akagi-yama and the Tanigawa Mountain Range, have been confirmed to exist . In addition, two new localities of *P. macroceras*, Mts. Hotaka-yama and Ojikazawa-no-kashira, which had not been previously recorded, were found. However, only a single locality of *P. ramosa*, a threatened species (Endangered in the Red List of Gunma Prefecture and Vulnerable in the Red List of the Ministry of the Environment of Japan), was confirmed to be present in the prefecture. The two species have extremely narrow environmental preferences and are restricted to specific environmental niches. The population size of both species at each microhabitat is small and there is a potential risk of disappearance of those localities in the future by the impacts of environmental stress or human activities. This study documents the current situation of the genus in Gunma Prefecture and suggests that urgent conservation is necessary to protect both the two species and their habitats in the prefecture.

Keywords: Distribution of *Pinguicula*, flora of Gunma, habitat, Lentibulariaceae, *P. macroceras*, *P. ramosa*

Editor: Anonymity requested.

Date of publication: 26 April 2022 (online & print)

Citation: Shimai, H. & T. Ohmori (2022). Distribution of the genus *Pinguicula* (L., 1753) (Lentibulariaceae) in Gunma Prefecture, Japan with new records. *Journal of Threatened Taxa* 14(4): 20848–20858. https://doi.org/10.11609/jott.7485.14.4.20848-20858

Funding: The authors receive no fundings for this project.

Competing interests: The authors declare no competing interests.

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Author contributions: Both authors equally contributed to the field surveys, data collection, and the preparation of this manuscript.

Acknowledgements: The authors are grateful to curators of herbaria for permission to study herbarium specimens. Thanks are also due to Dr. Atsushi Ebihara (National Museum of Nature and Science, Tsukuba, Japan) for providing the digital image of the specimen presented in this paper.

INTRODUCTION

Species of the genus *Pinguicula* L. (1753) (Lentibulariaceae) are relatively small herbs basically forming basal rosettes with adhesive carnivorous leaves. Over 90 species are distributed in Eurasia, North and South America, the Caribbean Islands, and Morocco (Casper 1966; Fleischmann & Roccia 2018), and approximately half of which are found in Mexico (Zamudio 2005). At least two species, *P. macroceras* Link (1820) and *P. ramosa* Miyoshi (1890), occur in Japan. In general, those species are found in nutrient-poor wet soil where other plant species are scarce.

Pinguicula macroceras was often treated as *P. vulgaris* L. var. *macroceras* (Link) Herder by Japanese botanists, but it is recognized as a distinct species in recent years (after Casper 1962). *P. macroceras* is widely distributed in the northern Pacific region, including Japan, the Kurils, Sakhalin, the Aleutians, Alaska, and western Canada to northern California. The holotype of the species, collected in Unalaska, Alaska and deposited in Botanic Garden and Botanic Museum Berlin (B), was lost during WWII (Casper 1962); however, the lectotype was recently designated by Domínguez et al. (2017).

The southernmost distribution of *P. macroceras* known in Japan is a limestone cliff at Mt. Ishidate-yama on the border of Kochi and Tokushima Prefectures, Shikoku Island (Yamanaka 1953; Komiya & Shibata 1998). In literature, the Botanical Society of Japan (1888) reported that R. Yatabe and some other botanists observed *Pinguicula* sp. (most likely *P. macroceras*) on Mt. Ishizuchi-san in Ehime Prefecture, which could be the westernmost distribution of the species; however, no specimens from the mountain have been found so far. Many localities are known particularly in the Chubu region (central Japan, particularly in Nagano Prefecture) and farther north. *Pinguicula macroceras* in the country are mostly restricted to occurring in higher mountains or deep gorges (Komiya & Shibata 1998). The species exceptionally occurs at low altitudes of 140–200 m along rivers in Gosen, Niigata Prefecture (Katagiri 1980; Komiya & Shibata 1998). The species is often found on limestone or serpentine rocks in the Chubu region and farther south while it is also found in peat or silt in northern Japan. The species is a relic species in the postglacial era (Komiya & Shibata 1998).

Pinguicula ramosa, described by Manabu Miyoshi, is endemic to Japan, specifically in Gunma and Tochigi Prefectures. It is confined to altitudes of 1,400–2,300 m in only a few mountains around Nikko City. The authority is often treated as *P. ramosa* 'Miyoshi ex Yatabe' since Casper's (1966) taxonomic monograph of the genus; however, it is correctly *P. ramosa* 'Miyoshi' (Shimai 2016). The voucher specimen stamped as 'TYPUS' in Koishikawa Botanical Garden, University of Tokyo (TI) was designated as the lectotype by Domínguez et al. (2017). The species is restricted to specific mountains in Gunma and Tochigi Prefectures, and the threatened status is Vulnerable (Ministry of the Environment of Japan 2020) and Endangered in Gunma Prefecture (Gunma Prefecture 2018). It is often found on vertical or overhanging cliffs formed by weathered tuff breccia. The habitat in Mt. Koshin-zan in Tochigi Prefecture, where the species were first discovered, is strictly protected as a special rank of the Natural Monument. Regarding the taxonomic rank, Tamura (1953) treated that it was an infraspecific taxon of *P. villosa* L. (1973), i.e., *P. villosa* L. var. *ramosa* (Miyoshi) Tamura (1953). However, *P. ramosa* is a distinct species morphologically (Komiya and Shibata 1998), cytologically (Casper and Stimper 2009), and phylogenetically (Shimai et al. 2021).

Gunma Prefecture (area of 6,362 km^2) is in the northern part of the Kanto region. The prefecture roughly has the Kanto Plain in the south and mountain ranges in the north. It is an inland prefecture without coastlines but there are many sources of the Tone-gawa River System. The climate of the prefecture is affected by both the Pacific Ocean side and the Sea of Japan side. Although the number of localities of *P. macroceras* in Gunma is fewer than that in neighboring Nagano or Niigata Prefecture, Gunma is biogeographically important because it borders the two prefectures, which geologically divide Western and Eastern Japan. Gunma and Tochigi are the only prefectures where the two *Pinguicula* species certainly occur. In Tochigi, *P. macroceras* is recorded from only two mountains, Mt. Nikko-Shirane-san and Mt. Nantai-san. Although more localities of *P. macroceras* are known in Gunma than Tochigi, the population size at each locality in Gunma is small and there is a risk of habitat reduction. Many high mountains and deep gorges prevent the thorough investigation of flora in Gunma, resulting in insufficient research in such inaccessible areas. In this study, we document the distribution of *Pinguicula* including both earlier records as well as newly found ones in Gunma Prefecture by our recent investigations to prevent the disappearance of the species.

MATERIALS AND METHODS

Herbarium specimens housed in museums and botanical gardens in the world were studied (mainly 2013–2020) and specimen data on the labels such as localities, collected years, and collectors were gathered. The localities in Gunma are summarized in Table 1, but detailed locations or coordinates are omitted to protect the habitats. After 1900, it was divided every 10 years, and collection records, if any, at each locality were presented in the table. The elevation and coordinate of each mountain are obtained from the database of the Geospatial Information Authority of Japan (https://www.gsi.go.jp/top.html), and those are of a representative peak of each mountain but do not necessarily indicate the exact location where the species can be found. A distribution map was produced based on the specimen records using GeoCat, Geospatial Conservation Assessment Tool (Royal Botanic Gardens, Kew; http://geocat.kew.org/), and the extent of occurrence (EOO) and the area of occupancy (AOO) were calculated by the program. The AOO was calculated by the default parameter of 2 km × 2 km (= 4 km^2). Two or more microhabitats close to each other (e.g., within 100 m) or two or more collection records from the same area were treated as a single locality. The coordinate datasets on GeoCat were then transferred to QGIS 3.14 to produce a distribution map (Figure 1). Even if other localities were found on literature or internet source, those were not recognized in this study unless specimens from there were found.

RESULTS

Specimens of *Pinguicula* collected in Gunma Prefecture were mostly found at herbaria in Japan, such as GMNHJ, KYO, TI, and TNS. Localities recognized are summarized in Table 1 and are individually discussed below.

Pinguicula macroceras Link

1. Mt. Akagi-yama (1,828 m, 36.560278, 139.193333) (Image 1A, B)

Mt. Akagi-yama (or also called Akagi-san), located ca. 20 km north-east of Maebashi, the prefectural capital of Gunma, is one of the symbolic mountains of the prefecture. It is a complex volcano although no volcanic activities have been recorded for ca. 30,000 years (Kobayashi & Nakamura 2001). The somma consists of

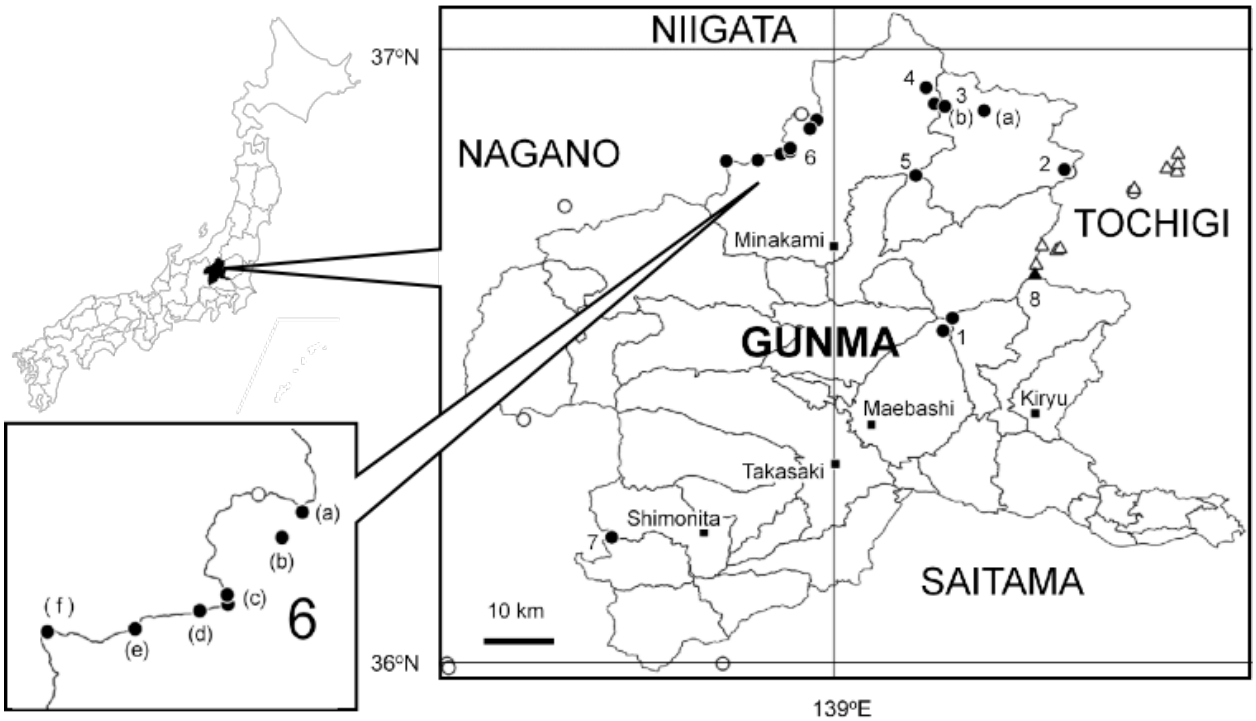

Figure 1. Distribution of two species of *Pinguicula* in Gunma Prefecture and surroundings: Closed circles—*P. macrocears* in Gunma | Open circles—*P. macroceras* in neighboring prefectures | Closed triangles—*P. ramosa* in Gunma | Open triangles—*P. ramosa* in Tochigi | Lines within Gunma Prefecture show municipal borders (as of 2019). Numbers correspond with those in the text: 1. Mt. Akagi-yama, 2. Mt. Nikko-Shirane-san, 3. Oze, 4. Naramata-gawa River, 5. Mt. Hotaka-yama, 6. Tanigawa Mountain Range, 7. Mt. Arafune-yama, 8. Mt. Kesamaru-yama.

Table 1. Observed specimens of *Pinguicula* in Gunma Prefecture. MAC = *P. macroceras*. RAM = *P. ramosa*. Localities are listed in alphabetical order. Numbers correspond with those in the text and Figure 1. [New] = new record reported in this study. X = specimen collected during the period. Voucher specimens are listed in the specimens examined section.

Species	Locality in Gunma	No.	Specimen record											
MAC	Akagi-yama, Mt. (Jizo-dake)	1					X	X	X				X	X
MAC	Akagi-yama, Mt. (Kurobi-san)	1	X		X	X								
MAC	Akagi-yama, Mt. (w/o location)	1						X	X			X	X	
MAC	Arafune-yama, Mt.	7							X					
MAC	Asahi-dake, Mt.	6 (1)								X	X			
MAC	Ayame-daira	3 (1)					X	X?						
MAC	Hotaka-yama, Mt. [New]	5												X
MAC	Kasagatake, Mt.	6 (2)												
RAM	Kesamaru-yama, Mt.	8								X			X	X
MAC	Mantaro-san, Mt.	6 (5)							X					X
MAC	Naramata-gawa River	4						X					X	
MAC	Nikko-Shirane-san, Mt.	2												X
MAC	Ojikazawa-no-kashira, Mt. [New]	6 (4)												X
MAC	Shibutsu-san, Mt. (NE slope)	3 (2)						X					X	
MAC	Shibutsu-san, Mt. (NW slope)	3 (2)											X	
MAC	Shibutsu-san, Mt. (w/o location)	3 (2)			X	X	X	X	X					
MAC	Tairappyo-yama, Mt.	6 (6)						X						
MAC	Tanigawa-dake, Mt.	6 (3)											X	X
MAC	Tanigawa-dake, Mt. (w/o location)	6 (3)			X		X	X	X			X		
			1900-1909	1910-1919	1920-1929	1930-1939	1940-1949	1950-1959	1960-1969	1970-1979	1980-1989	1990-1999	2000-2009	2010-2019

several peaks including Kurobi-san (1,828 m; the highest peak of the mountain), Komagatake (1,685 m), and Jizo-dake (1,674 m). There are a few lakes and ponds, e.g., Lakes Ono (or Onuma) and Kono (or Konuma), in the caldera.

In the mountain, the specimens of *P. macroceras* were collected mainly from Kurobi-san and Jizo-dake Peaks, but the former has no collection records after the 1930s. The specimens have been collected repeatedly from the latter peak and the species is present near the summit; however, the population size is declining rapidly since the soil there is getting dry. It was commonly seen at Jizo-dake Peak in the early 2000s but was only ca. 50 individuals in 2019. At Jizo-dake Peak, the species is found only in eroded wet black soil. The habitat is above the forest line with good sunlight which may result in dry soil and the consequent decline of population size. There are several herbarium specimens that say only 'Mt. Akagi-yama' on the labels (i.e., not specified exact peaks or locations).

Although no specimens have been found so far, Hattori (1908) wrote that numerous plants of *P. macroceras* were seen at Komagatake and Choshichiro-dake Peaks in the mountain. In July, the summit of Kurobi-san was purple in color by the flower of the species (Hattori 1909). Pictures in the book of Hattori (1908) showed that the summit of Kurobi-san was an open grassland at that time while the summit is mostly surrounded by trees, today. No plants were found at these peaks in our recent surveys.

2. Mt. Nikko-Shirane-san (2,578 m, 36.798611, 139.375833) (Image 1C, D)

Mt. Nikko-Shirane-san, a stratovolcano, is located on the border of Gunma and Tochigi Prefectures. It is the highest mountain in the Kanto region and northern Japan. The mountain is officially Shirane-san, but there are some other mountains that have the same name, so it is often called Nikko-Shirane-san to specify. The mountain, characteristically dome-shaped, is located in the western part of Nikko National Park (114,908 ha).

Due to ancient volcanic activities, a few lakes and

ponds have been formed. Relatively large numbers of *P. macroceras* are seen on the Tochigi side of the mountain. There was a record of the species from the Gunma side in literature, but it was thought to be extinct (Moriya 1976). However, we confirmed in 2019 that the species was still present there although less than 30 individuals. It grows among grasses so it may be difficult to find them unless they are in flower. Concerning its small population size, they may disappear from there in the future.

3. Oze National Park

Oze, highland wetlands on the Gunma, Niigata, and Fukushima prefectural borders, was formed by volcanic activities of Mt. Hiuchigatake (2,356 m) ca. 10,000 years before present. It roughly consists of Ozegahara (peatland), Oze-numa Pond, and a few mountains including Mts. Hiuchigatake and Shibutsu-san. Wetlands and ponds in a plateau provide characteristic vegetation with many rare and endemic plant species. Oze and its surroundings have been designated as Oze National Park (37,200 ha). It is an area that symbolizes the conservation of nature in Japan. At least two localities of *P. macroceras*, Ayame-daira and Mt. Shibutsu-san, are known in Oze.

(a) Ayame-daira (1,969 m, 36.900556, 139.244722)

Ayame-daira, with a gentle peak and mountain peatlands, is located in the southern part of the national park. Too many visitors caused erosions and it subsequently became bare ground at the top of Ayame-daira in the 1950s. Since the 1960s, a vegetation recovery program has been attempted by a few organizations and is yet on the way; therefore, the wetland is strictly protected. Some literature occasionally recorded that *P. macroceras* occurred there but only a single herbarium specimen from there has been found so far. We have confirmed in July 2020 that a small population of the species is present there. There is a specimen from Ozegahara, which might be collected at Ayame-daira (probably mislabeled), because the species is not present in Ozegahara.

(b) Mt. Shibutsu-san (2,228 m, 36.903611, 139.173333)

Mt. Shibustu-san, located at the westernmost of the national park, is composed of serpentines (Kawase et al. 2009). Some rare plant species (e.g., *Japonolirion osense* Nakai and *Arenaria katoana* Makino) are seen in the mountain (Tomimatsu et al. 2004; Kawase & Yumoto 2006; Kawase et al. 2009). There are many *P. macroceras* specimens previously collected at the mountain. Some location names on the northeastern slope of the mountain are specified on the specimen labels, but those could be within the same area. There is a specimen from the northwestern slope, but the area is designated as an environmental protection area by Gunma Prefecture and is restricted to access there. There were many specimens that say only 'Mt. Shibutsu-san' on the labels.

4. Naramata-gawa River watershed

Naramata-gawa River, which is upstream of Tone-gawa River, is originated in the Echigo Mountains. The area belongs to Minakami township in Gunma. *P. macroceras* was collected at one of the branch streams of Naramata-gawa River in 2003. There is another collection record from somewhere along Naramata-gawa River in 1955, but it is unclear if this location is identical with the former. No recent information is available.

5. Mt. Hotaka-yama (2,158 m, 36.805278, 139.132500) [New record] (Image 2A)

Mt. Hotaka-yama is often called Joshu-Hotaka-yama to distinguish it from Mt. Hotaka-dake (3,190 m; the third highest mountain in Japan) on the prefectural border of Gifu and Nagano. Mt. Hotaka-yama, an old volcanic mountain, is an independent peak located at the south of Mt. Shibutsu-san.

The specimen of *P. macroceras* was recently collected at the south-facing slope of Mt. Hotaka-yama on 16 August 2016 by T. Ohmori and H. Yoshii which is deposited in Gunma Museum of Natural History (GMNHJ). It is too dangerous to go off the mountain trails and the activities of researchers are restricted as there are many cliffs along streams and above the subalpine zone. Furthermore, there are many areas and mountains nearby, such as Oze, the Tanigawa Mountain Range, and Mt. Nikko-Shirane-san, which are more important in the field of botany, resulting in less exploration by botanists in Mt. Hotaka-yama. Those might be reasons why the species had not been discovered in the mountain until 2016.

6. Tanigawa Mountain Range

Strictly speaking, the Tanigawa Mountain Range is a part of the Mikuni Mountain Range. The Tanigawa Mountain Range, with several mountains, is on the prefectural border of Gunma and Niigata (sometimes called 'jo-etsu kokkyo'), and it depends on literature which mountains are included in the mountain range. In this study, it is defined that the range is from Mts. Asahi-dake and Kasagatake in the east to Mt. Tairappyo-yama in the west. Those mountains are connected by the Gunma ridge trail.

(a) Mt. Asahi-dake (1,945 m, 36.880556, 138.97250)

Mt. Asahi-dake is located in the eastern part of the mountain range. The specimen of *P. macroceras* was collected at the mountain in 1976 and 1981, but the specimen label did not show any exact location. No recent specimens have been found; however, the species is present according to information from climbers who visited the mountain. The species also occurs on Shimizu-toge Pass, on the Niigata side, ca. 2 km north-west of the summit of Mt. Asahi-dake.

(b) Mt. Kasagatake (1,852 m, 36.869444, 138.962778)

Mt. Kasagatake (or Mt. Okura-yama) is located ca. 1.5 km south-west of Mt. Asahi-dake. The specimen of *P. macroceras* was collected in 1965, and it is the only specimen found so far. The specimen label specifies as 'between Okura and Kasagatake', which is probably somewhere on a trail between Okura-one Ridge and the summit of Mt. Kasagatake (the trail is disused today). It is not confirmed whether the species is still present there.

(c) Mt. Tanigawa-dake (1,977 m, 36.837222, 138.930000 (Image 1E, F)

Mt. Tanigawa-dake, a serpentinous mountain, is located on the prefectural border of Gunma and Niigata. The mountain possesses two characteristic peaks, which are Oki-no-mimi (1,977 m) and Toma-no-mimi (1,963 m). A few localities of *P. macroceras* can be found around the peaks. Those microhabitats are covered by grasses; therefore, it is somewhat difficult to find the species unless they are in flower. There are not many individuals, often <50, within each microhabitat. There is a potential risk that they may disappear from there in the future due to ecological succession. Some other populations can be seen on a vertical cliff on the northeast side of the mountain, but it is impossible to approach there without climbing equipment.

(d) Ojikazawa-no-kashira (1,840 m, 36.829167, 138.912500) [New record] (Images 1G, H, 2B)

Ojikazawa-no-kashira is located between Mts. Tanigawa-dake and Mantaro-san (ca. 1.5 km west of the former). The north side of the mountain trail belongs to Niigata Prefecture. *P. macroceras* had not been collected before, but only a few plants were newly discovered in a grassland near the summit of the Gunma side on 07 July 2019, which the specimen collected by H. Shimai has been deposited in the National Museum of Nature and Science (TNS). There is a risk that the species could potentially disappear from there in the future since the locality is densely covered by grasses which is unfavorable for *P. macroceras*.

(e) Mt. Mantaro-san (1,954 m, 36.824167, 138.879167)

Mt. Mantaro-san, ca. 5 km west of Mt. Tanigawa-dake, is located on the Gunma ridge trail to Mt. Tairappyo-yama. Because of the relatively long trail, botanists rarely access the area. Approximately 100 plants were found on the ridge below the peak on 07 July 2019. This locality is about on the prefectural border of Gunma and Niigata. The microhabitat is also covered by grasses due to ecological succession , and the population may disappear in the future. It is unclear whether it is identical to the location below.

There was an earlier collection record of the species in the back of Kawafuru-onsen Spa. Although the exact location is unknown, it is assumed that it may be between a headwater stream of Akaya-gawa River and the ridge on the prefectural border, or near the ridge. The area is on the south slope of Mt. Mantaro-san, but the trail between the spa and the ridge is very long and rugged, requiring crossing streams; therefore, botanists usually do not enter such a tough route.

(f) Mt. Tairappyo-yama (1,984 m, 36.817500, 138.821667)

Mt. Tairappyo-yama, at the western edge of the Tanigawa Mountain Range, stands on the prefectural border of Gunma and Niigata, and it has peatlands near the summit (Sasaki & Kariya 2000). *P. macroceras* was collected from two locations on the Gunma side, but our surveys in 2018 and 2019 failed to find the species along the mountain trail. It may be possible that the species is still present away from the trail. Although we have not accessed the specimens, the species was also collected on the Niigata side of the mountain (Katagiri 1980).

7. Mt. Arafune-yama (1,423 m, 36.203889, 138.637222)

Mt. Arafune-yama, with a massive vertical rock cliff, is in the western part of Gunma (on the prefectural border of Gunma and Nagano). The existence of *P. macroceras*, collected on the Gunma side only once in 1960, was confirmed by the specimen only. No detailed location was mentioned on the specimen label except the name of the mountain. It is unclear whether the species is still present there; however, it is almost impossible to search for plants on the inaccessible massive rock cliff. The locality is not only the westernmost but also the southernmost for the species in Gunma.

***Pinguicula ramosa* Miyoshi**

8. Mt. Kesamaru-yama (1,961 m, 36.649444, 139.327222) (Image 1I, J)

Mt. Kesamaru-yama, a volcanic mountain on the prefectural border of Gunma and Tochigi, is located at the westernmost of the Ashio Massif. Mt. Kesamaru-

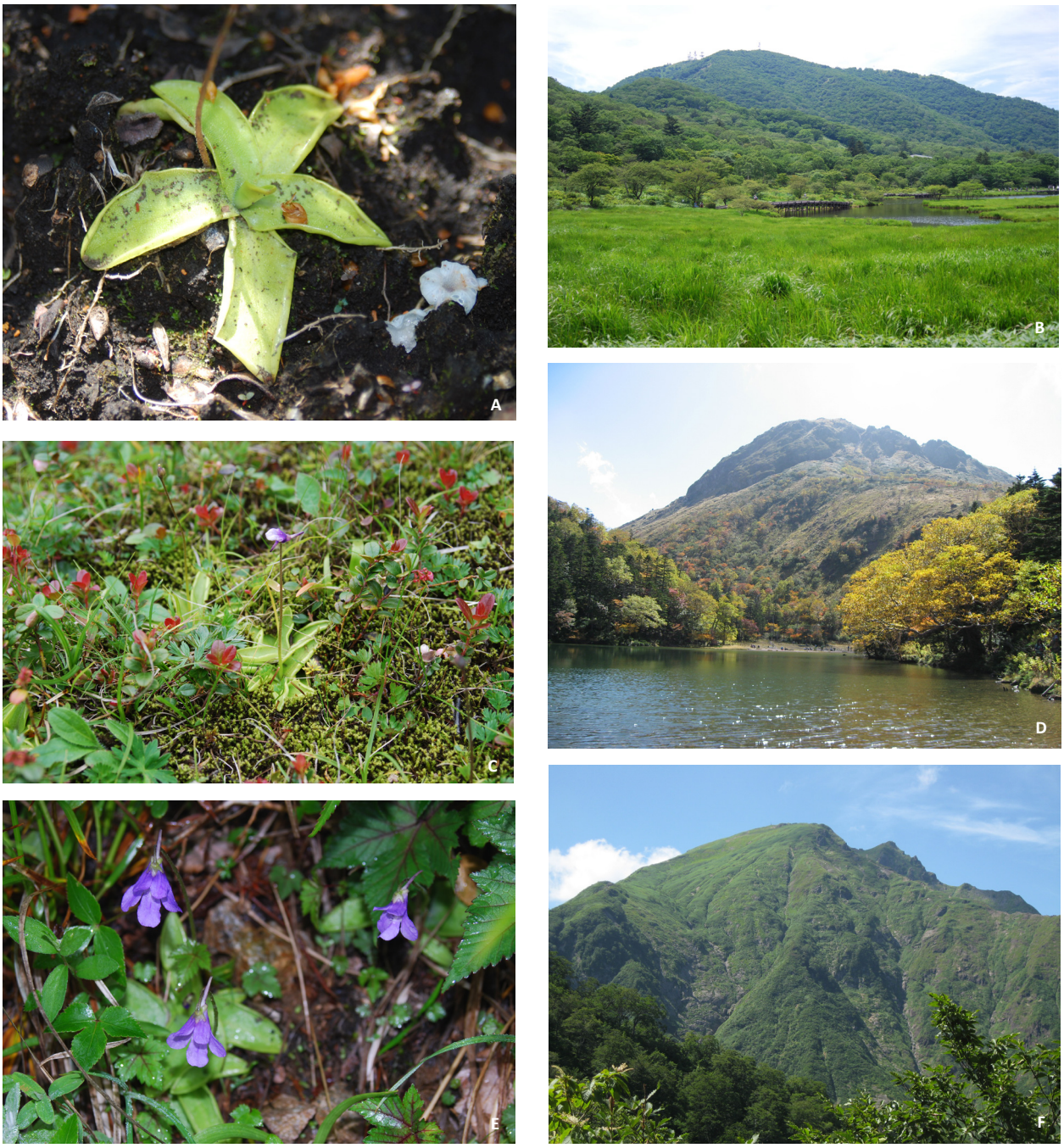

Image 1. *Pinguicula* species and their habitats in Gunma Prefecture: A, B—*P. macroceras* (16.vii.2018) and its habitat, Jizo-dake Peak in Mt. Akagi-yama; view from Kakumambuchi | C, D—*P. macroceras* (02.vii.2019) and its habitat, Mt. Nikko-Shirane-san | E, F—*P. macroceras* (07. vii.2019) and its habitat, Mt. Tanigawa-dake. © H. Shimai.

yama consists of a few peaks. The highest peak is a point at 1,961 m (no name for the peak), north of Ato-Kesamaru Peak (1,908 m). The species occurs on both Gunma and Tochigi sides of the mountain.

Ato-Kesamaru Peak is the only place where *P. ramosa* occurs in Gunma. Only four specimens from the Gunma side were confirmed to exist. Although there were a few other specimens saying only 'Mt. Kesamaru-yama' on the specimen label, no prefecture was specified. The species can be seen only on a vertical cliff of weathered tuff breccia on the mountain as also seen on Mts. Koshin-zan and Nantai-san in Tochigi. The species basically occurs below the tree line, but the habitat on the Gunma side has good sunlight compared with

Image 1. G, H—*P. macroceras* (07.vii.2019) and its habitat, Mt. Ojikazawa-no-kashira | I, J—*P. ramosa* (06.vi.2019) and its habitat, Mt. Kesamaru-yama; view from Tochigi side. © H. Shimai.

localities in Tochigi. The habitat receives direct sunlight in the morning, which may cause dry out the soil of the microhabitat. Minor collapses of the cliff seem to be relatively common, which may affect the habitat of the species. No *P. macroceras* has been found on Mt. Kesamaru-yama.

Distribution areas of *Pinguicula* in Gunma

In *P. macroceras* in Gunma, the EOO calculated by GeoCat was 2,458 km^2 and the AOO was 64.0 km^2, both of which suggested Endangered although the species is not listed in the Red List of Gunma Prefecture. The area of Gunma Prefecture is ca. 6,362 km^2; therefore, the EOO covers one-third of the prefecture. Although the GeoCat instruction suggests that it is possible to evaluate the threatened category at a regional level, it needs further studies whether this method can be applicable for such a widespread species. On the other hand, *P. ramosa* occurs only in a single locality in Gunma Prefecture, which is unable to calculate the EOO by GeoCat since the program requires at least three locations to evaluate the status. However, it is apparent that *P. ramosa* is an endangered species in Gunma.

DISCUSSION

The localities of *Pinguicula macroceras* within Gunma Prefecture are mostly restricted to above the subalpine zone, 1,500 m or higher, in the north (Figure 1). If some other localities outside of Gunma (e.g., Mts. Asama-yama and Iwasuge-yama in Nagano and Mt. Nantai-san in Tochigi) are included, those surround the northern half of Gunma Prefecture. The species is often found in alkaline soil (e.g., limestone or serpentine outcrops) in the Chubu region or farther south. However, the environmental preference of *P. macroceras* in Gunma is similar to that in the Tohoku region (e.g., in Mts. Akita-Komagatake, Nyuto-zan, and Hachimantai). *P. macroceras* in Gunma Prefecture tends to be found in acid peaty soil near snow patches or stream banks rather than alkaline soil, where the species is more often seen in the Chubu region and farther south (particularly at lower altitudes). It is highly possible that the species grows in extreme environments to avoid survival competitions with other plant species, but it may not strictly depend on the soil pH level. It is also probable that increasing pioneering plants, such as grasses, sasa bamboos, and

tall herbaceous plants (i.e., ecological succession) in the habitats, or erosions along mountain trails would be more serious causes for declining populations of *P. macroceras*. Furthermore, natural disasters, including heavy rains or furious typhoons, which tend to be increasing in recent years, may cause the distraction of the locality due to landslides.

Kurobi-san, one of the peaks at Mt. Akagi-yama, used to be famous for *P. macroceras*; however, the species has totally disappeared from there already. There is no recent information whether the species is still present in some localities (e.g., Mt. Arafune-yama) due to remote areas or inaccessible cliffs. Most of the localities of *P. macroceras* are within national parks, which are protected by law. Even within the protected areas, the microhabitats are covered by grasses (e.g., Mt. Tanigawa-dake), which are unfavorable for the species. In the current study, we report two new localities, but many localities in Gunma Prefecture have a small number of the species.

Regarding *Pinguicula ramosa*, large colonies were seen on both the Gunma and Tochigi sides of Mt. Kesamaru-yama before; however, those rapidly shrank in the last 50 years (Hiroshi Masuda pers. comm. vi.2019). On the Gunma side, we recently observed only a small number of *P. ramosa* plants on a vertical rock face. It is unclear how many plants are present there, but it is no doubt that the population size is very small. Dry soil and corruption of the rock face may cause the extinction of species on the Gunma side.

In addition, the localities of *P. macroceras* in other prefectures near the Gunma border are Mts. Asama-yama and Iwasuge-yama in Nagano, Nakatsu-gawa River in Saitama, Mts. Nantai-san and Nikko-Shirane-san in Tochigi. The localities of *P. ramosa* outside of Gunma are Mts. Kesamaru-yama, Nokogiri-yama, Koshin-zan, Nyoho-san, and Nantai-san in Tochigi.

Concerning the EOO in *P. macroceras*, it covers one-third of the area of Gunma Prefecture, but the status of the species including *P. ramosa* is not optimistic. Further studies of both species and their urgent conservation act in Gunma Prefecture are necessary. The current situation of the two species is recorded above, but there may be unknown localities in high mountains or deep gorges.

Image 2. Specimens from new localities: A—Mt. Hotaka-yama, 16.viii.2016, Ohmori and Yoshii 12056 (GMNHJ; as *P. vulgaris* L. var. *macroceras* (Pall. ex Link) Herder: forming hibernacula). B—near Ojikazawa-no-kashira Peak, 07.vii.2019, Shimai s.n. (TNS; as *P. vulgaris* L). Due to environmentally sensitive areas in the national parks, detailed information, such as landmarks and coordinates, on specimen labels has been removed.

Specimens examined

Pinguicula macroceras Link, Jahrb. Gewächsk. 1: 54 (1820).

JAPAN. **Gunma**: Mt. Akagi-yama, 20.vii.1952, Okuyama 10148 (TNS; as *P. vulgaris*); 04.vi.1961, Komiya s.n. (TNS); 01.viii.1962, Tanaka s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 29.vi.1999, Shibata s.n.

(TNS); 18.vi.2000, Komiya & Shibata s.n. (TNS). Mt. Akagi-yama, Jizo-dake, 26.vii.1948, Tanaka s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 30.vii.1950, Komiya s.n. (TNS); vi.1951, Komiya s.n. (TNS); vi.1952, Komiya s.n. (TNS); 13.vi.1954, Higuchi s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 1,400 m, 19.vi.1965, Fukuoka & Naruhashi 20 (KANA, KYO; as *P. vulgaris* var. *macroceras*); ca. 1,650 m, 08.vi.2001, Shimai s.n. (Nippon Dental Univ.); 1,640 m, 05.vi.2004, Yoshii s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 1,660 m, 17.vii.2018, Shimai s.n. (TNS). Mt. Akagi-yama, Kurobi-san, 25.vii.1903, Hayata s.n. (SAPS, TI; as *P. vulgaris*); 09.viii.1927, Kojima s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 12.vii.1928, Hara s.n. (TI; as *P. vulgaris*); 25.vii.1930, Shiobara s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 15.vi.1934, Saito s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 16.vi.1934, Fukushima s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*). Mt. Akagi-yama, between Onuma Lake and Jizo-dake, 1,400–1,700 m, 15.vi.1969, Konta 7707 (TNS; as *P. vulgaris*). Mt. Arafune-yama, 20.ix.1960, Satomi s.n. (TNS; as *P. vulgaris*). Mt. Asahi-dake, 24.vii.1976, Yoshizawa 761 (TNS; as *P. vulgaris*); 14.vii.1981, Haginiwa JH033382 (TNS; as *P. vulgaris* var. *macroceras*). Mt. Hotaka-yama, 16.viii.2016, Ohmori and Yoshii 12056 (GMNHJ; as *P. vulgaris* var. *macroceras*). Mt. Mantaro-san, 07.vii.2019, Shimai s.n. (TNS). Minakami, Upper stream of Kawafuru-onsen Spa; vi.1976, Miyamae s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*). Minakami, branch of Naramata-gawa River, 1,290 m, 25.viii.2003, Ohmori et al. 3540 (GMNHJ; as *P. vulgaris* var. *macroceras*). Naramata-gawa River, upper stream of Tone-gawa River, 20.vi.1955, Matsuda s.n. (TI). Mt. Nikko-Shirane-san, 21.vii.2019, Shimai s.n. (TNS). near Ojikazawa-no-kashira Peak, 07.vii.2019, Shimai s.n. (TNS). between Okura and Mt. Kasagatake, 29.vii.1965, Miyamae s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*). Oze, Ayamedaira, 23.vii.1947, Tanaka s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*). Ozegahara, 23.vii.1951, Ikoshi s.n. (TNS; as *P. vulgaris*). Mt. Shibutsu-san, 15.vii.1924, Takeda & Tatewaki s.n. (SAPS); 16.vi.1929, Hara s.n. (TI; as *P. vulgaris*); 13.viii.1931, Hoshi s.n. (KYO); 09.viii.1935, Ohwi & Tagawa 301 (KYO); 04.vii.1941, Hurusawa s.n. (TI; as *P. vulgaris*); 20.vii.1942, Satomi s.n. (KANA; as *P. vulgaris*); 19.vii.1946, Nakai 2694 (KYO; as *P. vulgaris*); 2,100 m, 05.viii.1949, Kawasaki 4363 (TNS; as *P. vulgaris*); 20.vii.1950, Tobe s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 27.vii.1951, Komiya s.n. (TNS); 30.vii.1952, Tamura s.n. (KYO); vi.1954, Komiya s.n. (TNS); 20.vii.1954, Asai s.n. (TI; as *P. vulgaris* var. *macroceras*); 22.vii.1954, Oda s.n. (Tochigi Pref. Museum; as *P. vulgaris* var. *macroceras*); viii.1954, Sugaya s.n. (TUS; as *P. vulgaris*); 02.viii.1969, Miyamae s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 29.viii.1969, Oze Conservation Center of Gunma Pref. s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*). Northeastern slope of Mt. Shibutsu-san, ca. 2,000 m, 17.vii.1950, Mizushima s.n. (TI; as *P. vulgaris* var. *macroceras*); 30.viii.1950, Komiya s.n. (TNS); 1,900–2,000 m, 04.vii.2003, Shimai s.n. (Nippon Dental Univ.). Northwestern slope of Mt. Shibutsu-san, 1,600 m, 05.viii.2001, Ohmori & Yoshii 1797 (GMNHJ; as *P. vulgaris* var. *macroceras*). Mt. Tairappyo-yama, East side, 1,900 m, 21.vi.1959, Hara s.n. (TI). Mt. Tairappyo-yama, between Tairappyo-goya Hut and summit, 12.vii.1957, Okuyama et al. 13691 (TNS). Mt. Tanigawa-dake, 1,900 m, 14.vii.1928, Hara 9602 (TI; as *P. vulgaris* var. *macroceras*); 06.vii.1948, Yamazaki & Ono 2913 (S, TI; as *P. vulgaris*); 08.viii.1949, Komiya s.n. (TNS); 08.vii.1951, Higuchi s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 24.vii.1951, Tobe s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 02.vii.1953, Kimura & Matsuda s.n. (TI; as *P. vulgaris* var. *macroceras*); 03.vii.1953, Komiya s.n. (TNS); 14.vii.1953, Kanai 382 (TI; as *P. vulgaris* var. *macrocarpa*); vii.1966, Yamazaki s.n. (TI); 01.viii.1961, Suto s.n. (GMNHJ; as *P. vulgaris* var. *macroceras*); 15.vii.1965, Komiya s.n. (TNS); 20.vii.1999, Komiya & Shibata s.n. (TNS); ca. 1,950 m, 23.viii.2004, Shimai s.n. (Nippon Dental Univ.); 03.viii.2018, Shimai s.n. (TNS); 07.vii.2019, Shimai s.n. (TNS). between Mt. Tanigawa-dake and Mt. Asahi-dake, 01.vii.1956, Harazawa s.n. (KANA).

Pinguicula ramosa Miyoshi, Bot. Mag. (Tokyo) 4: 315 (1890).

JAPAN. **Gunma**: Midori, Mt. Kesamaru-yama, 14.vi.1974, Suto s.n. (GMNHJ); 29.vi.2003, Shibata s.n. (Nippon Dental Univ.); 28.vi.2009, Yoshii et al. s.n. (GMNHJ); 06.vi.2019, Shimai s.n. (TNS).

Herbarium code: GMNHJ = Gunma Museum of Natural History | KANA = Kanazawa University | KYO = Kyoto University | S = Swedish Museum of Natural History | SAPS = Hokkaido University Museum | TI = University of Tokyo | TNS = National Museum of Nature and Science | TUS = Tohoku University.

All specimens in Nippon Dental University have been transferred to TNS.

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NAAS rating (India) 5.64

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Journal of Threatened Taxa

www.threatenedtaxa.org

ISSN 0974-7907 (Online) | ISSN 0974-7893 (Print)

April 2022 | Vol. 14 | No. 4 | Pages: 20811–20950
Date of Publication: 26 April 2022 (Online & Print)
DOI: 10.11609/jott.2022.14.4.20811-20950

Communications

Short Communications

Notes

Publisher & Host

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