

長野県・山梨県におけるリンゴ属の探索・収集

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Exploration and Collection of *Malus* Genetic Resources in Nagano and Yamanashi Prefectures.

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Summary

Wild genetic resources from indigenous populations of apple species in Nagano and Yamanashi Prefectures were examined and collected. A total of 29 accessions of apple genetic resources, including 15 from *Malus baccata* var. *mandshurica* and 14 from *M. toringo*, as well as 1 from *Pyrus ussuriensis* var. *hondoensis* were collected. The former two species were sympatrically distributed in four of the six areas surveyed in this study. Hybridization or introgression between them is suspected in these areas.

KEY WORDS: genetic resources, apple, *Malus*, Nagano, Yamanashi, Chubu

Introduction

There are four species of *Malus* (Rosaceae, Maloideae) that grow wild in Japan, as well as several cultivated species that originated from the Asian continent in ancient times or later, or were introduced from the Occident in modern times. These species have been explored by foreign and Japanese horticulturalists and botanists since the middle of the 19th century. As a result, several genetic resources or botanical living collections reported to have been introduced from Japan are now preserved in many facilities around the world. Unfortunately, there is little or no detailed collecting data on these materials, even for the plants deposited in the NIAS Genebank.

In addition, the Japanese provenance of some of these cultivated *Malus* plants is doubtful due to morphological differences with both wild and cultivated species found in Japan. An

extreme example is *Malus floribunda*. This species has been well utilized for ornamentals and for the breeding of apple scab resistance and was reported to have originated in Japan. However, neither wild nor cultivated plants of this *Malus* species have been identified in Japan. Thus, the origin of apple scab resistance of this species is still unknown.

We have studied the taxonomy and distribution of Japanese *Malus* species^{1), 2)}, and started to explore and collect genetic resources from wild populations³⁾, in order to construct core collections of them and for other purposes. This year we are surveying Nagano and Yamanashi Prefectures in the Chubu region, an area which marks the western and southern boundaries of the distribution of *Malus baccata* (L.) Borkh. var. *mandshurica* (Maxim.) C.K.Schneid. (“Ezo-no-koringo” in Japanese) in Japan. This species is distributed in isolated mountain pockets of this area since it grows wild in upper temperate zones (about 1,000 - 2,000 m height above sea level). We are also planning to collect *M. toringo* (Siebold) Siebold ex Vriese (“Zumi” or “Mitsuba-kaidou” in Japanese), which grows in similar habitats as the former species but is more common.

Methods

The first field survey was conducted in May and June of 2006 to discover wild trees in their native habitats, and to collect flower and fresh leaf samples for morphological and molecular studies. The second field survey was performed in September and October of 2006 to acquire scions for genetic resource collections. Voucher herbarium specimens were also collected in both surveys. Based on the information obtained from the preliminary field survey and from herbarium specimens preserved in various facilities in Japan, we traveled to the Fuji Mountains, Nyuugasa Mountains, Yatsugatake Mountains, Chichibu Mountains, Karuizawa High Plateau and Shiga-Kougen High Plateau to survey as much of the distribution area of *M. baccata* as possible.

Results

A total of 29 accessions of apple genetic resources were collected. Fifteen individuals of *Malus baccata* var. *mandshurica* were collected from four different mountains and 14 of *M. toringo* were collected from six mountains. We also found and collected one *Pyrus ussuriensis* var. *hondoensis* sample in the Nyuugasa Mountains, which we had not surveyed during the exploitation of *Pyrus* genetic resources in 2004⁴⁾.

The following are brief descriptions of the habitats of the collection sites.

1) Shiga-Kougen High Plateau

This plateau is situated from 1,500 - 1,700 m in elevation. Both species prefer moist places around ponds or moors so we especially searched such places. *Malus toringo* was more common and was found other ponds and moors in addition to our collection.

On the other hand, *M. baccata* var. *mandshurica* was very rare. Since this area is one of the most artificially exploited places in the present distribution area of this species in the Chubu region, this rarity is perhaps due to an artificially-induced decrease. However, considering that this is also the northern limit of the species' present distribution in this region²⁾, the population

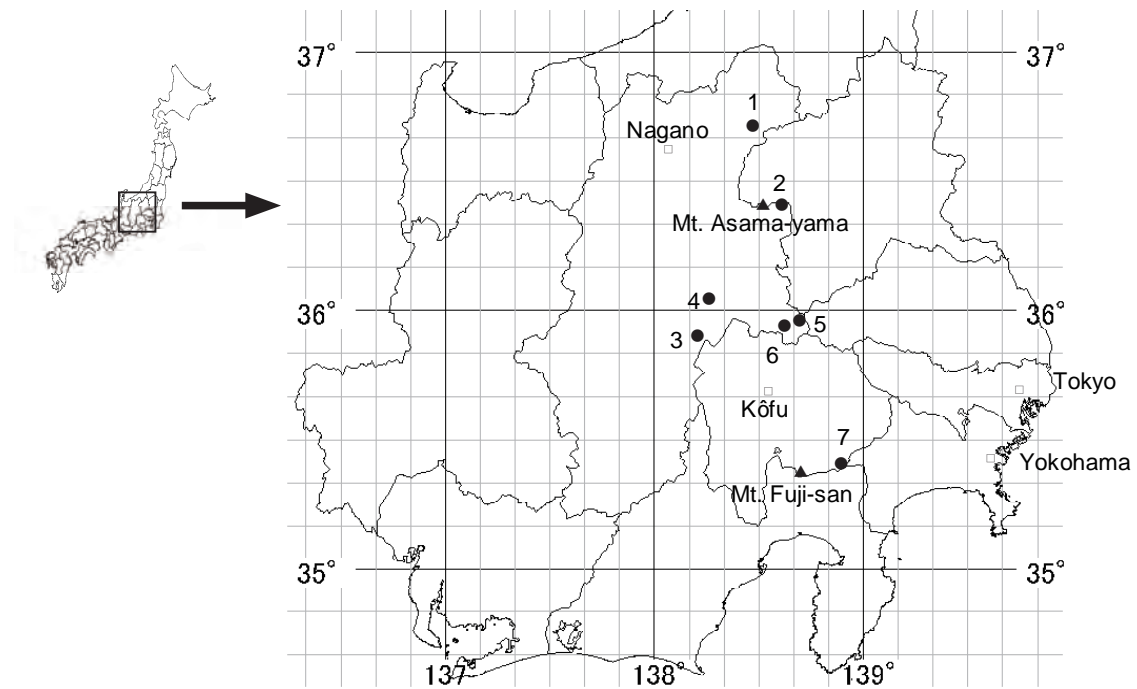


Fig. 1. Collection sites of *Malus* genetic resources in Nagano and Yamanashi Prefectures.

structure may possibly be fluctuated by the bottleneck effect if this paucity of individuals in the population is a natural phenomenon and this plant has occurred since geological age.

We also discovered a small population of *M. baccata* var. *mandshurica* at Nozori-ko Lake, about 12 km east of this plateau.

2) Karuizawa High Plateau

We collected two plants of *Malus toringo* at the border between Nagano and Gunma Prefectures. This species was common in this area from about 800 m to 1,700m in elevation. Here it grew in secondary deciduous forests dominated by *Quercus crispula* or *Q. serrata*, especially at forest margins. At one time, there had been extensive wetlands in the southern part of Karuizawa. But almost all of them were completely destroyed to develop leisure facilities. Some *M. toringo* trees were kept at these leisure facilities as ornamental trees.

3) Nyuugasa Mountains

Two moors, Oo-awara Moor and Nyuugasa Moor, are found in this area. We collected materials from the former moor, where about 50 individuals of *Malus baccata* var. *mandshurica* and a greater number of *M. toringo* were found. Both species were also found outside of the moors. *M. toringo* was distributed continuously in secondary forests from low elevation areas (about 1,000 m a.s.l.), while *Malus baccata* var. *mandshurica* grew only in areas surrounding the moors.

M. baccata var. *mandshurica* also occurs south of here, but the number of individuals is very limited⁵⁾. The population here is perhaps the southernmost one which contains a stable number of individuals.

We also collected one sample of *Pyrus ussuriensis* var. *hondoensis*, the first time we had

collected this material since we did not survey this area in our previous exploration for this tree⁴). This area is perhaps the only remaining indigenous habitat of this plant on the western side of the Itoigawa-Shizuoka Tectonic Line⁶).

4) Yatsugatake Mountains

The number of *Malus baccata* var. *mandshurica* in this area is undoubtedly the largest in the Chubu region. We can find this species in its preferred habitat from 1,300 m to 1,800 m in elevation throughout this area. We collected materials at a valley in the upper reaches of the Shibu-kawa River. The south bank of this river consists of gentle slopes, which might have been created by pyroclastic flow from the Yatsugatake Volcano. Some places along this bank have become wetlands and preferred habitat for two *Malus* species.

5) Chichibu Mountains

We have already revealed that *Malus baccata* var. *mandshurica* is distributed in the areas of Nagano and Yamanashi Prefectures of the Chichibu Mountains²). However, since the date from the preliminary survey and the herbarium specimens indicated that there may be only a limited number of individuals on the south side (Yamanashi Pref.) of the Mountains, we decided to survey the northwest side (Nagano Pref.). Here, *M. toringo* grew from lower elevations (less than 1,000 m) up to 1,600 m. *Malus baccata* var. *mandshurica* was generally found at higher elevations (1,400 m or more), and was most common in riparian deciduous forests in the upper reaches of the Chikuma-gawa River.

The microtopography of this locality is similar to that of the Shibu-kawa River Valley in the Yatsugatake Mountains. Gentle slopes and wetlands occur throughout the area. It should be noted that this terrain had been created by non-volcanic geographical processes.

6) Fuji Mountains

In this area, only *Malus toringo* occurs but it is very common. We surveyed from the northwest slope of Mikuni Touge Pass to the eastern shore of Yamanakako Lake.

7) Overview

Both species occurred in four of the six areas surveyed in this study. At the Chikuma-gawa River site in the Chichibu Mountains, the two species grew separate from one another, but in the Shiga High Plateau, Nyuugasa Mountains and Yatsugatake Mountains, they grew sympatrically. Hybridization or introgression between them is suspected in these latter areas because these two species have almost no interspecific physiological mating barriers. Some of the bastard genetic resources and cultivated plants of the ostensibly Japanese provenance may possibly be of hybrid origin.

We are planning to investigate the origin and analyze the molecular phylogeny and population genetic structure of Japanese *Malus* populations using the materials collected in this study. We expect the results will come in useful for unlocking the mystery of the origin of *Malus* genetic resources as well as for revealing their genetic diversity.

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和文摘要

長野県と山梨県において、リンゴ属野生遺伝資源の探索・収集を行い、エゾノコリンゴ15点とズミ14点を収集した。この他にアオナシ1点も収集した。調査した6地域のうち4地域では、エゾノコリンゴとズミは同所的に生育しており、雑種形成を行っている可能性が疑われた。

Table 1. List of *Malus* and *Pyrus* genetic resources collected in Nagano and Yamanashi Prefectures.

Collection Name	Species	Date	Place	Municipality	Pref.	Locality No.(Fig.1)	Longitude(E) (ddd-mm-ss)	Latitude(N) (dd-mm-ss)	Alt. (m)	Field No.
NAGANO MALUS COL.NO.2006-1	<i>Malus baccata</i> var. <i>mandshurica</i>	9/10/2006	around Ichi-numa Pond, Hirao	Yamanouchi-machi	Nagano	1	138-28-47	36-43-7	1410	Sg-b14
NAGANO MALUS COL.NO.2006-2	<i>Malus toringo</i>	9/10/2006	around Biwa-ike Pond, Hirao	Yamanouchi-machi	Nagano	1	138-28-57	36-43-07	1400	Sg-t23
NAGANO MALUS COL.NO.2006-3	<i>Malus toringo</i>	9/10/2006	around Biwa-ike Pond, Hirao	Yamanouchi-machi	Nagano	1	138-28-57	36-43-07	1400	Sg-t25
NAGANO MALUS COL.NO.2006-4	<i>Malus baccata</i> var. <i>mandshurica</i>	9/10/2006	around Ichi-numa Pond, Hirao	Yamanouchi-machi	Nagano	1	138-28-47	36-43-7	1410	Sg-b13
NAGANO MALUS COL.NO.2006-5	<i>Malus toringo</i>	9/11/2006	in a moor near of Shizen-kyouiku-en, Hirao	Yamanouchi-machi	Nagano	1	138-29-39	36-42-43	1560	Sg-t7
NAGANO MALUS COL.NO.2006-6	<i>Malus baccata</i> var. <i>mandshurica</i>	9/11/2006	near Sachino-yu, Hidadoko	Yamanouchi-machi	Nagano	1	138-29-23	36-41-40	1640	Sg-b3
NAGANO MALUS COL.NO.2006-7	<i>Malus baccata</i> var. <i>mandshurica</i>	9/11/2006	near Sachino-yu, Hidadoko	Yamanouchi-machi	Nagano	1	138-29-05	36-42-14	1560	Sg-b7
NAGANO MALUS COL.NO.2006-8	<i>Malus toringo</i>	9/12/2006	near the border of Gunma Pref.	Karuziwa-machi	Nagano	2	138-34-15	36-25-10	1370	Kr-t17
NAGANO MALUS COL.NO.2006-9	<i>Malus toringo</i>	9/12/2006	near the border of Gunma Pref.	Karuziwa-machi	Nagano	2	138-35-11	36-25-13	1350	Kr-t23
NAGANO MALUS COL.NO.2006-10	<i>Malus baccata</i> var. <i>mandshurica</i>	10/3/2006	in Oo-araha Moor	Hase-mura	Nagano	3	138-10-57	35-53-07	1815	Ng-b5
NAGANO MALUS COL.NO.2006-11	<i>Malus baccata</i> var. <i>mandshurica</i>	10/3/2006	east of Oo-araha Moor	Fujimi-machi	Nagano	3	138-10-57	35-53-13	1820	Ng-b11
NAGANO MALUS COL.NO.2006-12	<i>Malus baccata</i> var. <i>mandshurica</i>	10/3/2006	in Oo-araha Moor	Hase-mura	Nagano	3	138-10-57	35-53-07	1815	Ng-b22
NAGANO MALUS COL.NO.2006-13	<i>Malus baccata</i> var. <i>mandshurica</i>	10/3/2006	north of Oo-araha Moor	Hase-mura	Nagano	3	138-10-42	35-53-21	1825	Ng-b61
NAGANO MALUS COL.NO.2006-14	<i>Malus toringo</i>	10/3/2006	in Oo-araha Moor	Hase-mura	Nagano	3	138-10-57	35-53-07	1815	Ng-t18
NAGANO MALUS COL.NO.2006-15	<i>Malus toringo</i>	10/3/2006	in Oo-araha Moor	Hase-mura	Nagano	3	138-10-57	35-53-07	1815	Ng-t19
NAGANO MALUS COL.NO.2006-16	<i>Malus baccata</i> var. <i>mandshurica</i>	10/4/2006	around upstream of Shibu-kawa River	Chino-shi	Nagano	4	138-18-00	36-02-02	1645	Ts-b105
NAGANO MALUS COL.NO.2006-17	<i>Malus baccata</i> var. <i>mandshurica</i>	10/4/2006	around upstream of Shibu-kawa River	Chino-shi	Nagano	4	138-19-14	36-01-59	1780	Ts-b201
NAGANO MALUS COL.NO.2006-18	<i>Malus baccata</i> var. <i>mandshurica</i>	10/4/2006	around upstream of Shibu-kawa River	Chino-shi	Nagano	4	138-18-26	36-02-02	1675	Ts-b202
NAGANO MALUS COL.NO.2006-19	<i>Malus toringo</i>	10/4/2006	around upstream of Shibu-kawa River	Chino-shi	Nagano	4	138-18-26	36-02-02	1675	Ts-t201
NAGANO MALUS COL.NO.2006-20	<i>Malus toringo</i>	10/4/2006	around upstream of Shibu-kawa River	Chino-shi	Nagano	4	138-18-09	36-02-01	1655	Ts-t209
NAGANO MALUS COL.NO.2006-21	<i>Malus toringo</i>	10/4/2006	around upstream of Shibu-kawa River	Chino-shi	Nagano	4	138-18-09	36-02-01	1655	Ts-t210
NAGANO MALUS COL.NO.2006-22	<i>Malus baccata</i> var. <i>mandshurica</i>	10/5/2006	around upstream of Chikuma-gawa River	Kawamami-mura	Nagano	5	138-43-05	35-56-57	1450	Kw-b4
NAGANO MALUS COL.NO.2006-23	<i>Malus baccata</i> var. <i>mandshurica</i>	10/5/2006	around upstream of Chikuma-gawa River	Kawamami-mura	Nagano	5	138-42-54	35-57-0	1480	Kw-b6
NAGANO MALUS COL.NO.2006-24	<i>Malus baccata</i> var. <i>mandshurica</i>	10/5/2006	around upstream of Chikuma-gawa River	Kawamami-mura	Nagano	5	138-42-40	35-57-15	1460	Kw-b10
NAGANO MALUS COL.NO.2006-25	<i>Malus baccata</i> var. <i>mandshurica</i>	10/5/2006	around upstream of Chikuma-gawa River	Kawamami-mura	Nagano	5	138-42-33	35-57-18	1450	Kw-b18
NAGANO MALUS COL.NO.2006-26	<i>Malus toringo</i>	10/5/2006	Megurime-daira	Kawamami-mura	Nagano	6	138-38-51	35-54-59	1520	Kw-t202
NAGANO MALUS COL.NO.2006-27	<i>Malus toringo</i>	10/5/2006	Megurime-daira	Kawamami-mura	Nagano	6	138-38-37	35-54-42	1580	Kw-t205
YAMANASHI MALUS COL.NO.2006-1	<i>Malus toringo</i>	10/7/2006	the top of Mikuni-touge Pass	Yamanakako-mura	Yamanashi	7	138-54-56	35-24-19	1170	Ymk-t1
YAMANASHI MALUS COL.NO.2006-2	<i>Malus toringo</i>	10/7/2006	eastshore of Yamanaka-ko Lake	Yamanakako-mura	Yamanashi	7	138-53-55	35-25-41	980	Ymk-t18
NAGANO PYRUS COL.NO.2006-1	<i>Pyrus ussuriensis</i> var. <i>hondoensis</i>	10/4/2006	near Kubikiri-shimizu	Fujimi-machi	Nagano	3	138-10-29	35-53-37	1835	Ng-1



Photo 1. An indigenous habitat of *Malus baccata* var. *mandshurica* and *M. toringo*. Deciduous shrub vegetation dominated by these two species has developed at the margin of a high moor. Oo-awara Moor, Hase-mura, Nagano Pref. (Nyuugasa Mountains).



Photo 2 Infructescence of *Malus baccata* var. *mandshurica*. Near Sachino-yu, Hiradoko, Yamanouchi-machi, Nagano Pref. (Shiga Kougen High Plateau).



Photo 3 Infructescence of *Malus toringo* (red fruit type). In Oo-araa Moor, Hase-mura, Nagano Pref. (Nyuugasa Mountains).



Photo 4. Infructescence of *Malus toringo* (yellow fruit type). Around the upper reaches of the Shibukawa River, Chino-shi, Nagano Pref. (Yatsugatake Mountains).