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Review

Native fruit tree genetic resources in Japan

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The diversity of climate, from subarctic to subtropical, and the complex geological history of Japan have produced a rich biodiversity. The flora includes several hundred species of native woody plants with edible fleshy fruits or nuts. People have eaten them from prehistoric times until about a half century ago. In Hokkaidō and the Ryūkyū Islands nut species had an important role in the diet, but fleshy fruits were also eaten until recently. Only *Castanea crenata* and a few minor species became domesticated as edible fruit trees in pre-modern times. Recently, *Vitis coignetiae*, *Lonicera caerulea*, *Akebia quinata*, *Akebia trifoliata*, *Stauntonia hexaphylla*, and *Actinidia arguta* have entered small-scale cultivation. The conservation of the germplasm of many of these native species, both *in situ* and *ex situ*, is precarious.

Key Words: native species, fruit tree, nut, biodiversity, cultivated plants, ethnobotany.

Introduction

Biodiversity in Japan

The Japanese archipelago is located on the east coast of the Asian continent. The diversity of its climate, from subarctic to subtropical, with high humidity and precipitation throughout has produced a rich biodiversity (Iwatsuki *et al.* 1993–2016, Ohwi 1965). The connection with the continent several times before the last glacial maximum may have promoted migration from north and south to produce a flora with mixed subarctic, temperate, and subtropical elements. By contrast, its isolation after the last glacial maximum may have stimulated the phylogenetic differentiation of taxa from the continental mother taxa. However, this biodiversity hotspot (Mittermeier *et al.* 2004) is also one of the most populous regions in the world. The population pressure poses threats to wild ecosystems both directly via exploitation and indirectly via environmental degradation. More than 2000 species of flora are now threatened (Ministry of Environment of Japan 2012).

Definition of Japanese native fruit trees in this review

Japan has about 5000 species of seed plants (Kajita 2003). About 1000 species are woody, either trees, shrubs, or vines (Satake *et al.* 1989), and these include many fleshy fruit and nut species. In addition, some species were introduced in the Middle Ages or before. Formerly, some commercial fruit species, including *Pyrus pyrifolia* (Burm. f.) Nakai and *Amygdalus persica* L. (=*Prunus persica* (L.) Batsch), were thought to have originated from native plants (e.g., Kikuchi 1948). Now they are considered to have been introduced in pre-modern times ("archaeophytes"), though empirical confirmation is still rare (e.g., Iketani *et al.* 2010a, 2012). These introduced plants (listed in **Table 1**) are excluded from subsequent treatment in this review.

In a broad sense, all non-poisonous fleshy fruits and nuts are edible, and people might have eaten them, especially during times of famine. However, this review covers only plants that were eaten regularly. It excludes plants used only as folk medicine or to produce fruit liquor.

This review covers species supported by archeological evidence (e.g., Terasawa and Terasawa 1981), old historical documents (e.g., Fujiwara *et al.* 927), or ethnological information (e.g., Sarashina and Sarashina 1976); species that are now commercially grown or marketed even at a minor scale; and species with edible congeners in other regions of the world. In all, 70 genera are included (**Table 2**).

Usage of scientific names and Romanization of Japanese in this review

As this review lists many species unfamiliar to breeding science and horticulture, a simple standard for the usage of scientific names is necessary. The review uses names adopted in Yonekura (2012), which is a thorough compilation of the scientific names of vascular plants in Japan, including recent nomenclatural changes after Iwatsuki *et al.* (1993–2016), and which is now the *de facto* standard. Full details, including updates, are available on line (Yonekura and Kajita 2003–).

The scientific name of a taxon may be very long and

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Table 1. Fruit trees introduced to Japan in pre-modern times

Species	Period of Introduction	Literature[1] (introduced)	Literature[1] (native)
Gingko biloba L.	13–14th Century	Hori and Hori (1997)	
Ficus carica L.	17th Century?	Kikuchi (1948)	
Eriobotrya japonica (Thunb.) Lindl.	Prehistoric	Kobayashi (1990)	Kikuchi (1948)
Malus asiatica Nakai	12th Century?	Kitamura (1979)	
	14–15th Century	Kobayashi (1990)	
Armeniaca vulgaris Lam. (*Prunus armeniaca* L.)	Prehistoric	Kikuchi (1948), Kobayashi (1990)	
Armeniaca mume (Siebold et Zucc.) de Vriese (*Prunus mume* Siebold et Zucc.)	Prehistoric	Kitamura (1979) Kobayashi (1990)	Kikuchi (1948)
Prunus salicina Lindl.	Prehistoric	Kitamura (1979) Kobayashi (1990)	Kikuchi (1948)
Amygdalus persica L. (*Prunus persica* (L.) Batsch.	Prehistoric	Kitamura (1979) Kobayashi (1990)	Kikuchi (1948)
Pyrus pyrifolia (Burm.f.) Nakai	Prehistoric	Kobayashi (1990)	Kikuchi (1948)
Diospyros kaki Thunb.	Prehistoric	Kobayashi (1990)	Kikuchi (1948)
Vitis vinifera L.	7th Century?	Kobayashi (1990)	
Ziziphus jujuba Mill.	6–7th Century	Kobayashi (1990)	
Citrus spp.	6–7th Century	Kobayashi (1990)	
Punica granatum L.	12th Century?	Kikuchi (1948)	

[1] Literature supporting the hypothesed origin.

detailed (e.g., using the ranks of subspecies and variety) owing to recent reclassifications based on the broad species concept. This review uses detailed names only when necessary. Otherwise, a simple binomial combination of genus and species is used for convenience and simplicity.

Romanized transcriptions of Japanese names mostly follow the Library of Congress and American Library Association (2012), with a few exceptions such as proper nouns.

Regional usage of fruits and nuts

Japanese fruit and nut trees grow from the subarctic to the subtropics. The Ainu people, the indigenous inhabitants of subarctic Hokkaidō, ate fruits of *Empetrum nigrum* L. and *Vaccinium oxycoccos* L., which grow in both uplands and lowlands. They also ate fruits of *Phellodendron amurense* Rupr., *Malus baccata* (L.) Borkh. var. *mandshurica* (Maxim.) C. K. Schneid., *Padus avium* Mill. (=*Prunus padus* L.), *Rosa rugosa* Thunb., *Rubus idaeus* L., and *Sambucus racemosa* L., all of which are distributed in the upper-elevation deciduous forest zone and grow widely in the lowlands of Hokkaidō. Species of *Ribes*, *Malus*, *Rubus*, *Lonicera* and *Vaccinium* might have also been eaten.

These plants also grow at high altitudes in temperate Honshū but were rarely or never used there, possibly because their habitats were remote from settlements. One exception is *Vaccinium uliginosum* L., which grows wild above 1500 m a.s.l. in volcanic desert vegetation on Mount Asama and surrounding areas, where local people gathered wild fruits for decades after World War II (Koike and Miyagawa 1974). This practice is now prohibited, because most of the habitat is protected. Another exception is *Pyrus ussuriensis* var. *ussuriensis* in the upper deciduous forest zone in northern Honshū (Iwate Prefecture). Trees introgressed with archaeophytic *P. pyrifolia* grow wild in this area as well as in cultivation (Iketani *et al.* 2010a, Katayama and Uematsu 2006). Whether this species began to be used before or after introgression is still unknown. This is discussed in more detail by Katayama (2016) in this issue.

Archaeological studies of the utilization of plants in the subtropical Ryūkyū Islands were limited until recent reports of the remains of seeds or stones of many species (e.g., Omatsu and Tsuji 2001). On the other hand, ethnological studies are abundant (e.g., Amano 1982, Sato and Nohara 1997, Tawada 1982). According to these studies, people may have eaten many tree fruits, especially during times of famine (**Table 2**).

Nut species have been more generally utilized than fleshy fruit species since the hunting-and-gathering age (Taneishi 2014). The most important reason is that nuts are rich in carbohydrates or fats and are thus highly nutritious. Hatakeyama (1989) estimated that wild nuts might have supplied about one-third of the daily energy intake during winter in mountainous settlements of the Kitakami Mountains, where the harvest of cereal crops had been always insufficient. Another reason is that nut genera such as *Quercus* and *Castanea* are usually dominant in vegetation, and people can easily gather nuts in abundance. Although *Aesculus* species contain saponins and most *Quercus* species contain tannins, people have used them for food by leaching out these components. Nuts have been utilized in almost all areas from Hokkaidō to the Ryūkyū Islands. The Ainu people used only nuts of *Quercus*, although *Aesculus* is common in southern Hokkaidō (Watanabe 1975). People continued to eat wild nuts until the 1940s in some regions (Hatakeyama 1989, in the Kitakami Mountains; Sato and Nohara 1997, in

Table 2. List of Japanese native fruit and nut species. The arrangement of families and scientific names follows Yonekura (2012)

Family	Genus	Edible part[1]	Growth Form[2]	Life Form[3]	Vegetation Zone[4]	Floristic Region[5]	Beginning of Cultivation[6]	Congeneric cultivated species[7]	Number of species[8]	Number of threatened taxon[9]	Representative (possibly) utilized species	Literature[10]
Cycadaceae	*Cycas*	N	S	E	ST	A, Oc			1		*C. revolta* Thunb.	Sa, Ta
Pinaceae	*Pinus*	N	S, T	E	Sa-ST	N		+	7	1	*P. koraiensis* Siebold et Zucc.	
Cephalotaxaceae	*Cephalotaxus*	N	S, T	E	Tm-W	EA			8		*C. harringtonia* (Knight ex Forbes) K.Koch	W
Taxaceae	*Torreya*	N	S, T	E	Tm-W	W			1		*T. nucifera* (L.) Siebold et Zucc.	T, W
Laulaceae	*Cinamomum*	F	S, T	E	ST, T	A			7	2	*C. yabunikkei* H.Ohba	Sa
	Litsea	F	S, T	E	W-T	A			9	1	*L. coreana* H.Lév.	Sa
Pandanaceae	*Pandanus*	F	T	E	ST	OW		+	1	1	*P. odoratissumus* L.f.	Am, Om, Ta, Sa
Lardizabalaceae	*Akebia*	F	V	D	Tm-W	EA	R		2		*A. quinata* (Houtt.) Decne., *A. trifoliata* (Thunb.) Koidz.	F, Ma
	Stauntonia	F	V	E	W	EA	R		1		*S. hexaphylla* (Thunb.) Decne.	F
Grossulariaceae	*Ribes*	F	S	D	Tm	N		+	9	3	*R. japonicum* Maxim., *R. latifolium* Janz.	Ma, S
Vitaceae	*Ampelopsis*	F	V	D, E	Tm-W	AA			4		*A. glandulosa* (Wall.) Momiy.	W
	Vitis	F	V	D	Tm-ST	N	R	+	5	2	*V. coignetiae* Pulliat ex Planch, *V. flexuosa* Thunb.	Hk, Om, S, T, Ta
Rosaceae	*Amelanchier*	F	S, T	D	Tm	N		+	1		*A. asiatica* (Siebold et Zucc.) Endl. ex Walp.	
	Cerasus	F	T	D	Tm-W	EU		+	10	4	*C. jamasakura* (Siebold ex Koidz.) H. Ohba	
	Cragaegus	F	T	D	Tm	N		+	2	2	*C. chlorosarca* Maxim.	
	Malus	F	T	D	Tm	N		+	5	2	*M. toringo* (Siebold) Siebold, *M. baccata* Borkh.	S
	Padus	F	T	D	Tm	N		+	4		*P. avium* Mill.	Ai
	Pyrus	F	T	D	Tm	EU	O	+	2	2	*P. ussuriensis* Maxim.	Ma
	Rhaphiolepis	N	S	E	W	EA			1		*R. indica* (L.) Lindl.	Sa, Ta, W
	Rosa	F	S	D	Tm-W	N	R		12	2	*R. rugosa* Thunb.	Fu, Hk, S
	Rubus	F	S	D, E	Tm-W	N		+	44	10	*R. idaeus* L.	F, S, Sa, T, Ta
	Sorbus	F	S, T	D	Tm	N		+	4		*S. commixta* Hedl.	
Elaegnaceae	*Elaeagnus*	F	S, T, V	D, E	Tm-W	N	R	+	16	5	*E. multiflora* Thunb.	Ma, S, T, Sa, Ta
Rhamnaceae	*Berchemia*	F	S, T	D, E	Tm-W	W			5		*B. lineata* (L.) DC.	Ta
	Sageretia	F	S, T	D, E	W-ST	W			1		*S. thea* (Osbeck) M.C. Johnst.	Ta
Moraceae	*Bloussonetia*	F	S, T	D	Tm-W	EA			3		*B. papyrifera* (L.) l'Hér. ex. Vent.	Om, W
	Ficus	F	S, T	D, E	W-ST	T		+	15	2	*F. erecta* Thunb.	F, T, Ta, W
	Morus	F	S, T	D	W	AA		+	4	1	*M. australis* Poir.	Om, Sa
Fagaceae	*Castanea*	N	T	D	Tm-W	N	O	+	1		*C. crenata* Siebold et Zucc.	F, Fu, Ht, M, T, W
	Castanopsis	N	T	E	W	EA			2		*C. sieboldii* (Makino) Hatus. ex T.Yamaz. et Mashiba	Om, M, Ta, W
	Fagus	N	T	D	Tm	N			2		*F. crenata* Blume	M, W
	Lithocarpus	N	T	E	W-T	AA			2		*L. edulis* (Makino) Nakai	F, M, Om, Ta, W
	Quercus	N	T	D, E	Tm-W	N			15	1	*C. crispa* Blume, *C. serrata* Murray	Fu, Ht, M, Om, S, T, Ta, W
Myricaceae	*Myrica*	F	T	E	W	N	O	+	2		*M. rubra* Lour.	Om, Sa, T, Ta, W
Juglandaceae	*Juglans*	N	T	D	Tm	N		+	1		*J. mandshurica* Maxim.	Fu, Hk, Ma, M, S, T, W
Betulaceae	*Corylus*	N	S	D	Tm	N		+	2		*C. heterophylla* Fisch. ex Besser	F, W
Celastraceae	*Euonymus*	N	S, T, V	D, E	Tm, W	N			19	6	*E. carnosus* Hemsl.	Ta
	Gymnosporia	N	S	E	ST-T	W			1	1	*G. diversifolia* Maxim.	Sa

Table 2. (continued)

Family	Genus	Edible part[1]	Growth Form[2]	Life Form[3]	Vegetation Zone[4]	Floristic Region[5]	Beginning of Cultivation[6]	Congeneric cultivated species[7]	Number of species[8]	Number of threatened taxon[9]	Representative (possibly) utilized species	Literature[10]
Elaeocarpaceae	*Elaeocarpus*	N	T	E	W-T	OW			4	1	*E. japonicus* Siebold et Zucc.	Om, Ta
Euphobiaceae	*Mallotus*	N	S, T	D, E	W-T	OW			3		*M. japonicus* (L.f.) Müll.Arg.	W
Phyllantaceae	*Antidesma*	F	S, T	E	W-T	OW			4		*A. japonicum* Siebold et Zucc.	Ta
	Bischofia	F	T	E	ST-T	OW, Oc			1		*B. javanica* Blume	Sa, Ta
Salicaceae	*Idesia*	F	T	D	Tm-W	EA			1		*I. poplycarpa* Maxim.	L, Om, Ta
Calophyllaceae	*Calophyllum*	F	T	E	ST-T	T			1		*C. inophyllum* L.	Ta
Combretaceae	*Terminalia*	N	T	D, E	ST-T	OW, Oc			2		*T. catappa* L.	Ta
Mytaceae	*Syzigium*	F	S, T	E	ST-T	A, Oc		+	2		*S. buxifolium* Hook. et Arn.	Ta
Melastomataceae	*Melastoma*	F	S	E	ST-T	A, Oc			2	2	*M. candidum* D.Don	Ta, Sa
Anacardiaceae	*Choerospondias*	F	T	D	W	EA			1	1	*C. axillaris* (Roxb.) B.L.Burtt et A.W.Hill	W
Sapindaceae	*Aesculus*	N	T	D	Tm	N			1		*A. turbinata* Blume	Ht, M, W
Rutaceae	*Phellodendron*	F	T	D	Tm	EA			1		*P. amurense* Rupr.	Fu, Hk
	Toddalia	F	V	W	ST-T	A			1		*T. asiatica* (L.) Lam.	Ta
Malvaceae	*Firmiana*	F	T	D	ST-T	OW			1		*F. simplex* (L.) W.F.Wight	Ta
Santalaceae	*Buckleya*	N	S	D	Tm-W	AA			1		*B. lanceolata* (Siebold et Zucc.) Miq.	Ma
Cornaceae	*Cornus*	F	T	D	Tm-W	N		+	4	2	*C. kousa* Buerger ex Hance	
Sapotaceae	*Planchonella*	F	S, T	E	ST-T	T			2		*P. obovata* (R.Br.) Pierre	Ta
Pentaphyllacae	*Adinandra*	F	S, T	E	ST-T	OW, Oc			2		*A. ryukuensis* Masam.	Ta
Ebenaceae	*Diospyros*	F	T	D, E	Tm-ST	T		+	6	2	*D. japonica* Siebold et Zucc.	Ma, Sa, T, Ta
Primulaceae	*Ardisia*	F	S, T	E	W-T	T			8	2	*A. quinquegona* Blume, *A. sieboldii* Miq.	Ta, Sa
Theaceae	*Camellia*	N?	S, T	E	W	EA			4		*C. japonica* L.	Sa, W
Symplocaceae	*Symplocos*	F	S, T	D, E	Tm-T	T			24	3	*S.* sp. (undetermined)	Sa
Actinidiaceae	*Actinicia*	F	V	D, E	Tm-W	EA	R	+	4		*A. arguta* (Siebold et Zucc.) Planch. ex Miq, *A. polygama* (Siebold et Zucc.) Planch. ex Maxim., *A. rufa* (Siebold et Zucc.) Planch. ex Miq.	Fu, Hk, Om, S, Ta, W
	Sauraria	F	S, T	E	ST-T	AA			1		*S. tristyla* DC.	Ta
Ericaceae	*Empetrum*	F	S	E	Sa	A			1		*E. nigrum* L.	Fu, Hk
	Vaccinium	F	S	D, E	Sa-W	N	R	+	19	5	*V. oxycoccos* L., *V. oldhamii* Miq, *V. uliginosum* L.	Hk, S, Sa, Ta
Boraginaceae	*Ehretia*	F	T, S	D, E	W-T	T			4		*E. dicksonii* Hance, *E. microphylla* Lam.	Am, Om, Ta
Oleaceae	*Ligustrum*	F	S, T	D, E	Tm-W	W			9	1	*L. japonicum* Thunb.	Sa
Goodeniaceae	*Scaevola*	F	S, V	E	ST-T	T			1		*S. taccada* (Gaetrn.) Roxb.	Ta
Adoxaceae	*Sambucus*	F	S	D	Tm	N		+	2		*S. racemosa* L.	Ai
	Viburnum	F	S, T	D, E	Tm-T	N			16	3	*V. suspensum* Lind.	Ma, Sa
Caplifoliaceae	*Lonicera*	F	S	D	Tm-W	N	R	+	23	14	*L. caerulea* L.	Ma, S
Total									387	84		

1: F, fleshy part; N, nut. 2: S, shrub; T, tree; V, vine. 3: D, deciduous; E, evergreen. 4: Sa, subarctic; Tm, temperate; W, warm temperate; ST, subtropical; T, tropical. 5: A, Asian; AA, Asia-American; EA, East Asian; EU, Eurasian; N, Northern Hemisphere; OW, Old world; Oc, Oceanian; T, Tropical; W, Worldwide. 6: O, Old (pre-modern); R, Recently (after World War II). 7: Presence of congeneric edible cultivated species in other countries. 8: Number of species in the genus native to Japan (Yonekura 2012). 9: Ministry of Environment of Japan (2012). 10: Ai, Ainu Museum (2015); Am, Amano (1982); F, Fujiwara *et al.* (927); Fu, Fukuoka (1995); Hk, Hokkaido Institute of Public Health (2015); Ht, Hatakeyama (1989); L, Liu (1988); Ma, Matsushima *et al.* (2013); M, Matsuyama (1982); Om, Omatsu and Tsuji (2001); S, Sarashina and Sarashina (1976); Sa, Sato and Nohara (1997); T, Terasawa and Terasawa (1981);Ta, Tawada (1982); W, Watanabe (1975).

the Ryūkyū Islands).

Large seeds of some non-amentiferous species such as *Terminalia* and *Euonymus* have been used in the Ryūkyū Islands but their dietary use is almost unknown in mainland Japan (**Table 2**). It is perhaps because they commonly grow in that Islands. Other large-seeded species in addition to the Fagaceae, *Juglans*, and *Aesculus* may also have been eaten in Honshū and Hokkaidō if thinking the high dietary value of seeds.

Domestication of Japanese native wild fruit trees

Domestication in pre-modern times

Humans arrived in Japan around 35 000 years BP or later (Hudson 2007, Keally 2009). During the hunting-and-gathering age, people gathered and ate native fruits, as well as other wild plant and animal foods. These wild plants continued to be utilized after the beginning of agriculture (Terasawa and Terasawa 1981), but only a few became domesticated, such as the vegetable species *Cryptotaenia canadensis* (L.) DC. subsp. *japonica* (Hassk.) Hand.-Mazz., *Petasites japonicus* (Siebold et Zucc.) Maxim., and *Dioscorea japonica* Thunb. Although not important vegetables now, they might have been eaten before the modern age.

Among the native species listed (**Table 2**), *Castanea crenata* is the only one to become a major cultivated crop. It is also one of the few species domesticated in pre-modern times, along with *Myrica rubra* and *Pyrus ussuriensis* var. *ussuriensis*. Cultivation of *C. crenata* may have begun in prehistoric times, and its utilization for timber was also important in ancient times (Amino 2001). *Myrica rubra* grows wild in evergreen forests in middle and western Japan and has long been used as firewood. Its cultivation as a fruit tree may have begun in the late Edo period (19th century). However, the present leading cultivars are said to have been introduced from China (Wada 2000).

This paucity of cultivated native species was perhaps influenced by the presence of many introduced fruit trees. Large fleshy fruits are lacking among Japanese native species. Mammal-dispersed fruits, which are usually larger than bird-dispersed fruits, are rare among Japanese temperate species, occurring only in *Akebia*, *Stauntonia*, *Actinidia*, *Pyrus*, *Chaenomeles*, and *Cornus kousa*. The first three have been locally commercialized in modern times, as described below. Subtropical genera with mammal-dispersed fruits, such as *Syzygium* and *Toddalia*, have not been cultivated.

Recent domestication

High economic growth and cultural westernization after World War II increased the diversity of diet and foodstuffs in Japan. The consumption of fruits increased in both quantity and quality (such as jams, juices, and confectioneries). However, consumption stagnated and fell after the high economic growth ended, and some production areas tried to convert existing crops into new products (Uchiyama 1996). In areas depopulated by the high economic growth, various projects for reactivation of the local economy have been attempted since the 1960s. In the agricultural sector, fruit crops were developed as specialty products and matched with tourism strategies. Fruits and nuts are produced not only as regular products, but also as value-added products for gifts and souvenirs.

Although major fruits such as citrus, apple, and table grape are grown for product differentiation strategy, some minor fruits such as introduced berry and tropical fruit species also have a role. The most specialized products are newly domesticated native fruit trees. Among 8 genera with 11 species (**Table 3**), *Vitis coignetiae* and *Actinidia* spp. (*A. arguta*, *A. polygama* and *A. rufa*) have congeneric major fruit species, *V. vinifera* and *A. deliciosa*, respectively. *Vaccinium* also has many cultivated species, including blueberry and cranberry, in temperate and subarctic climate zones in other countries. *Lonicera caerulea* is also cultivated in

Table 3. New commercial cultivation of Japanese native fruit trees

Species	Production (t)		Representative Regions	Source
	2003	2012		
Akebia quinata and *A. trifoliata*	25.7	8.9	Yamagata, Ehime, Akita	
Stauntonia hexaphylla			Shiga	1)
Vitis coignetiae	135.6	186.7	Iwate, Yamagata, Hokkaidō	
Rosa rugosa			Hokkaidō, Aomori	2), 3)
Elaeagnus multiflora			Aomori	4)
Vaccinium oldhamii			Fukushima, Nagano, Nara	5), 6), 7)
Actinidia arguta	13.1	10.6	Fukushima, Kagawa, Yamagata	
A. polygama	1.9	—	Akita	
A. rufa			Miyazaki	8)
Lonicera caerulea	60.0	90.2	Hokkaidō, Aomori	

Production data were drawn from the website of the Ministry of Agriculture, Forestry, and Fisheries (http://www.e-stat.go.jp/SG1/estat/List.do?lid=000001129267)

Information on other plants was based on the following websites: 1) http://www.nube.jp/mube.html, 2) http://www.n-slow.com/item_detail/itemCode,su-1591/, 3) http://www.umai-aomori.jp/know/sanchi-report/146.phtml, 4) http://www.morikaju.jp/kudamono-natu.html, 5) http://www.nico2farm.jp/?page_id=21, 6) http://www.iijan.or.jp/oishii/products/fruit/post-1424.php, 7) http://natsuhaze.com/index.html, 8) http://www.yappamiyazaki.jp/store/search.php?codeNumber=1265765213

Russia and North America. Recently, Japanese cultivars were introduced into the USA and their adaptability to the climate was evaluated (Hummer *et al.* 2012, Thompson and Chaovanalikit 2002). The other five genera do not have any other major species grown for food in other countries. The most notable are *Akebia* (*A. quinata* and *A. trifoliata*) and *Stauntonia* (*S. hexaphylla*), both endemic to East Asia (Takhtajan 1986), and thus almost unknown in the West as fruit.

As these native species have a niche market, both their area and quantity of production are limited, and production has fluctuated. Except for *Vitis coignetiae* and *Lonicera caerulea*, the commercial cultivation of these native plants is extremely limited, possibly with as few as half a dozen growers at the fewest.

Although species of *Pinus*, *Amelanchier*, *Cornus*, *Crataegus*, and *Sorbus* are cultivated in other parts of the world, Japanese species are not utilized. They may have been eaten by indigenous people, but archaeological or ethnological evidence is lacking. The rarity of *Crataegus* and *Sorbus* (except for *S. commixta*) in Honshū and further south may be a reason. Seed of *Pinus* has been imported from Korea since the Middle Ages (von Verschuer 2006). However, there is no evidence for the utilization of Japanese species. Only imported seeds might have been consumed, and historical references (e.g., Minamoto 930s) might have been nothing more than citations from the Chinese literature. Although *Pinus* is common in the Japanese flora, *P. koraiensis*, which is the main edible species, is rare and may have been neither cultivated nor collected in the wild.

Future conservation

Horticultural and breeding studies have included Japanese wild species of *Vitis*, *Malus*, *Pyrus*, and *Actinidia*, which are congeneric with major fruit tree species, along with other wild species (e.g., Janick and Moore 1996, Moore and Ballington 1990). However, the conservation of these wild species, both *in situ* and *ex situ*, is inadequate: 84 taxa in **Table 2** are nominated in the Japanese National Red List (Ministry of Environment of Japan 2012), including two species of *Vitis* (*V. amurensis* and *V. romanetii*), two of *Malus* (*M. hupehensis* and *M. spontanea*), and two of *Pyrus* (*P. calleryana* and *P. ussuriensis*). The Red List only contains threatened plants and has no legal standing for the prohibition of picking and selling. *Ex situ* conservation is also precarious. Until recently, the NIAS Genebank, which is the Japanese national genebank for agricultural crops, has held few or no germplasm accessions of these native species. Other facilities such as botanical gardens are in a similar situation. To address this lack, extensive explorations have been performed for *Pyrus* (Iketani *et al.* 2005, 2006, 2008, Iketani and Mase 2009), *Malus* (Iketani *et al.* 2006, 2007, 2008, Iketani and Mase 2009, 2013, 2016), and *Vitis* (Iketani *et al.* 2014) in the past 10 years.

Recent advances in molecular population genetics have revealed that a species can be genetically differentiated when a genetic barrier among subpopulations exists. Therefore, a widely distributed species is likely to be differentiated where geographical barriers to gene flow, such as seas or high mountains, intervene, unless long-distance dispersal is possible. For example, *Pyrus ussuriensis* (*sensu lato*) is widely distributed in northeastern China, eastern Russia (Amur to Primorsky), the Korean Peninsula, and central and northern Honshū. Iketani *et al.* (2010a, 2012) revealed that native populations on the Asian continent, in central Honshū, and in northern Honshū are highly differentiated. Thus, it will be necessary to evaluate genetic differentiation within taxa to maximize the collection of genetic diversity.

Conservation of minor plants is more problematic, especially for the purpose of agricultural genetic resources. Their economic importance is limited. Basic information such as past ethnological utilization is necessary, as well as research for agricultural and industrial utilization. For example, Matsushima *et al.* (2013) newly reported several edible uses of plants on the basis of interviews in a mountain village in central Honshū. For the conservation of these species, several explorations have been performed (Iketani *et al.* 2010b, Ito 2011, 2012, Ito and Sugawara 2006, 2007, 2008, 2009, 2010). The collected germplasm is conserved in NIAS Genebank (http://www.gene.affrc.go.jp/index_en.php), along with the abovementioned *Pyrus*, *Malus*, and *Vitis* germplasm.

Preservation of collected germplasm also has difficulty because most of fruit trees have to be stored in the form of living plants. As it costs enormously, only national or international organizations have been capable to preserve fruit tree genetic resources. However, smaller organizations such as local governments and communities, private companies, non-governmental organizations and farmers could have a role (Frese *et al.* 2014, Maxted *et al.* 2011). We have to seek a new way that enables their participation. In Japan, on farm conservation of local vegetables can be cited as examples (Nishikawa 2012). Similar approaches in minor fruits and local fruit landraces could be possible by combining various potential benefits of germplasm collections such as local culture, education and tourism, not only economic ones.

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