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ORNAMENTAL AROIDS (ARACEAE) IN CHINA

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Антуриум является весьма популярным декоративным растением в Китае. Однако, статус его культивирования и потенциал развития все еще слабо изучены. В данном исследовании приведены подходы к его полевому изучению. Результаты свидетельствуют, что около 120 видов экзотического антуриума культивируется в качестве декоративных растений в Китае, таких как *Anthurium*, *Philodendron*, и *Zantedeschia*. В Китае имеется большое биоразнообразие Araceae. Наиболее распространенными природными декративными растениями являются *Alocasia odora* и *Leucocasia gigantea*. Многие другие природные виды антуриума имеют высокий потенциал для будущего садового возделывания в Китае.

Key words: *Alocasia odora*; *Araceae*; *биоразнообразие*; *Китай*; *Leucocasia gigantea*; *декоративный антуриум*.

Introduction

China has been identified as one of 17 richest biodiversity countries of the world. Among these mega-biodiversity countries, Brazil, China, Indonesia, Mexico and Columbia are five nations with most vascular plant species, which are 32,364, 29,650, 29,375, 25,036 and 24,500 species, respectively [1]. Many vascular plants have been cultivated as ornamentals. In particular, the China-originated vascular plants have made great contributions to the world horticulture and gardens. Ernest Henry Wilson (1876-1930), a western plant hunter and botanist, collected and shipped about 2,000 species of living ornamentals and many herbarium specimens from Asia to Europe and North America. Most of his collections were gathered from China in 1899–1918. He published a famous book named "*China, Mother of Gardens*", in which he dubbed China as the "Mother of Gardens" [2]. Since 1920s, Wilson's collections have become important components of introduced flora of western gardens and cities, and have been widely used in breeding, including selecting varieties and hybridizing cultivars. Some other western plant hunters and travelers also collected many China-originated plants and transferred to the West. The Scottish botanist Robert Fortune (1812–1880), for example, at the Royal Botanic Garden Edinburgh, and later in the Horticultural Society of London's garden, introduced more than 100 Chinese native plant species into western gardens in 1848–1851 [3]. In the cultivated flora of western gardens, the China-originated species improved plant biodiversity in both temperature and humid warm regions. The representatives of arbor species include *Gingko biloba*, *Davidia involucrata*, *Magnolia liliflora*, *Prunus serrulata*, and many conifers. Shrubs sometimes occupy the major proportion of a garden, such as *Rhododendron* spp., *Rosa* spp., *Paeonia* spp., *Berberis* spp., *Cotoneaster* spp., *Hydrangea* spp., *Spiraea* spp., *Syringia* spp., *Viburnum* spp., *Buddleja* spp., *Philadelphus* spp., and *Euonymus* spp. Famous herbaceous ornamentals such as lilies, lotus, primroses, daily lilies, chrysanthemums and orchids are mostly from China.

Aroids are plants in the family Araceae, known as *Arum* family. Members in the family are normally perennial herbaceous with rhizomes or tubers living in diverse habits

including climbers, floating aquatics, epiphytes, helophytes, pachycaul shrubs, and geophytes. Their inflorescence is composed of a spadix, which is almost always surrounded by a modified leaf called a spathe. In monoecious aroids (possessing separate male and female flowers, but with both flowers present on one plant). The spadix is usually organized with female flowers towards the bottom and male flowers towards the top. About 110 genera and 3,500 species of aroids have been recorded in all parts of the world but mostly distributed in tropical and subtropical regions especially in the New World tropics [4]. *Acorus* had been removed from Araceae and become an independent family, Acoraceae [5]. On the other hand, Lemnaceae (including 5 genera), had been integrated into Araceae.

Anthurium, *Colocasia esculenta* (taro), *Xanthosoma roseum* (elephant ear) and *Zantedeschia* are well-known members in Araceae. Within this family, there are the largest inflorescence in the world which is *Amorphophallus titanum* (Titan arum), and the smallest seed plants in the world (duckweeds, especially *Wolffia angusta* is only 0.3 x 0.6 mm). The family possesses a lot of beautiful plants such as *Aglaonema*, *Alocasia*, *Anthurium*, *Caladium*, *Cryptocoryne* (many popular aquarium plants), *Dieffenbachia*, *Epipremnum*, *Monstera*, *Philodendron*, *Spathiphyllum*, *Zamioculcas* and *Zantedeschia*. Taro, elephant ear, *Amorphophallus konjac* and *Monstera deliciosa* provide food values. *Rhaphidophora* is very important in Southeast Asia tropical rainforests while *Philodendron* is essential in the ecosystems of the Neotropical rainforests.

As a component of Chinese flora, Araceae is also abundant in the country, with 26 genera and 181 species, in which 72 species are endemic [4]. Some aroids have been cultivated in China as crops for more than 2,000 years. Three crops are with very high values both in Chinese history and nowadays. They are taro (*Colocasia esculenta*, a common food crop), konjac (*Amorphophallus konjac*, a medicinal and industrial crop), and *Ban Xia* (*Pinellia ternata*, an important herbal medicinal crop) [6].

In recent 30 years, aroids have become very popular in China. Mostly they are grown as important potted indoor ornamentals for their beautiful foliage and inflorescence. They are also cultivated for cutting flowers and gardens or landscapes. Many exotic ornamental aroids are introduced in recent decades, such as *Aglaonema*, *Anthurium*, *Caladium*, *Dieffenbachia*, *Philodendron*, *Spathiphyllum*, and *Zamioculcas*. The native aroids of China are also with aesthetic values. Some species have widely been used as indoor ornamentals and garden plants. However, the species number of ornamental aroids is still a question mark. Other issues related to ornamental aroids are also kept unknown. The present paper tries to answer some relevant questions.

Objectives and research methods

The objectives of this paper are to identify the species number of ornamental aroids in China, to reveal the cultivation status, and to assess development potential of native aroids in China with aesthetic values.

The electronic tools including Google Scholar, PubMed, Scopus, Web of Science and the Chinese databases such as VIP and Wanfang were used in the study. The general information, related literatures, and scientific names of ornamental aroids were obtained from these resources.

The exotic aroids have been investigated in urban areas. Resident districts, parks, botanical gardens, hotels, restaurants, conference centers and resorts had been visited randomly to interview issues related to the uses of ornamental aroids, especially the exotic species. Over 300 people had been interviewed; most of interviewees are from Yunnan, Hunan, Guangdong and Beijing. Participatory observation method was also adopted in the urban areas.

The authors, especially the first author, have investigated aroids in China and neighboring countries for more than 20 years. We also participated in the collection and

conservation of genetic resources of wild plants, including the approaches of seed bank and *in vitro* preservation of ornamental aroids. The methods of plant taxonomy, ethnobotany, seed biology, biotechnology, ecology, molecular biology, and horticulture had been adopted to investigate germplasm resources, seed vitalities, propagation properties, genetic diversity, growth and development, and others. *Alocasia*, *Amorphophallus*, *Arisaema*, *Colocasia*, *Epipremnum*, *Leucocasia*, *Pinnellia*, *Pothos*, *Remusatia*, *Rhaphidophora* and other genera had been emphasized.

Results and discussion

1. Exotic ornamental aroids in China

Our investigations showed that aroids have become very popular as ornamentals in China. As listed in Table 1, about 120 species in 14 genera of exotic aroids have been introduced as ornamentals. *Zamioculcas zamiifolia* was newly introduced ornamental plant, while the others have been grown in China for more than 30 years. The most popular exotic aroids are *Anthurium*, *Epipremnum*, *Spathiphyllum* and *Philodendron*. They are grown as garden plants in southern China, and as potted indoor ornamentals in northern China. Other groups are also very common, such as *Aglaonema*, *Dieffenbachia*, *Zantedeschia*, *Alocasia* and *Monstera*, in the whole country.

Taking *Anthurium* as an example, there are some enterprises in China to breed, cultivate, produce and trade *Anthurium*, both potted plants and cut flowers. A few enterprises are large-scaled, such as Anthura in Songming of Yunnan Province, and Jianye Green Base in Yanling of Henan Province. *Cryptocoryne* is the biggest group with about 30 ornamental species (including hybrids) introduced from southeastern Asian countries, particularly Borneo. They have been in cultivation in the western aquarium hobby since the late 18th century, although it was not until the 1960s that more than a handful of species was known and became more common in the hobby. Since 1980s, *Cryptocoryne* plants have attracted the Chinese enthusiasms of aquarium plants. The common species are *Cryptocoryne affinis*, *C. beckettii*, *C. cordata*, *C. walkeri*, and *C. wendtii*.

Many varieties or cultivars of exotic ornamental aroids have been grown in China as both garden plants and indoor ornamentals. More cultivars are from *Aglaonema*, *Anthurium*, *Dieffenbachia*, *Epipremnum* and *Zantedeschia*. For instance, 'Chalit's Fantasy', 'Curtisii', 'King of Siam', 'Manila', 'Manila Whirl', 'Silver Bay', 'Silver King', 'Silver Queen', 'Snow Queen', 'Treubii', and 'White Tip' are famous cultivars of *Aglaonema* grown in China.

Table 1

Common exotic ornamental aroids grown in China

No.	Scientific name	Origin	Grown area	Frequency
1	*Aglaonema* (ca. 10 spp.)	Southeast Asia	Whole country	★★★★★
2	*Alocasia* (ca. 6 spp.)	Southeast Asia	Whole country	★★★★
4	*Anthurium* (ca. 20 spp.)	South America	Whole country	★★★★★★
5	*Caladium* (4 spp.)	South America	Southern China	★★
6	*Cryptocoryne* (ca. 30 spp.)	Southeast Asia	Whole country	★★★
7	*Dieffenbachia* (ca. 20 spp.)	Tropical America	Whole country	★★★★★
8	*Epipremnum aureum*	Indonesia	Whole country	★★★★★★
9	*Monstera deliciosa*	Central America	Southern China	★★★★
10	*Philodendron* (ca. 20 spp.)	Tropical America	Whole country	★★★★★★
11	*Spathiphyllum* (ca. 10 spp.)	Tropical America	Whole country	★★★★★★
12	*Syngonium podophyllum*	Tropical America	Southern China	★★★
13	*Zamioculcas zamiifolia*	Eastern Africa	Whole country	★★★
14	*Zantedeschia* (ca. 5 spp.)	East, Central and Southern Africa	Southern China	★★★★

A few ornamental aroids had escaped into the wild habits and may become invasive species. Some species in *Cryptocoryne*, *Epipremnum* and *Syngonium* are considered invasive weeds in the tropics of southern China. These groups should be under monitoring when growing in the tropics.

2. Aroids native to China

There is rich diversity of aroids in China. In total 26 genera and 181 species had been reported, including 72 species endemic to the country [4]. The new aroids continue to be described [7][8]. Over 10 species will be added to the Chinese aroid list after the publication of *Flora of China* (Araceae, vol. 23) in 2010.

In China's tropical and subtropical regions, aroids demonstrate great diversity in local vegetations, including epiphytic, epilithic, aquatic, and terrestrial habitats. *Rhaphidophora*, *Amydrium*, *Scindapsus* and *Pothos* are important components of local ecosystems. They are big plants climbing on trees or cliffs in rainforests and evergreen broadleaved forests. *Lasia spinosa*, *Colla palustris*, *Cryptocoryne* spp., *Pistia stratiotes* and duckweeds are aquatic aroids. *Remusatia* spp., *Amorphophallus yuloensis*, *Pinnellia hunanensis* and others are epiphytic or epilithic.

Their propagation strategies are also various, by producing seeds, stolons, tubercles, bulbils and other vegetative organs. Some species of *Amorphophallus*, *Colocasia* and *Steudnera* produce stolons and tubercles for propagation, rather than producing seeds. *Amorphophallus yuloensis* and *A. bulbifer*, *Remusatia* spp., and *Pinnellia* spp. produce bulbils for vegetative propagation.

China is the diversity center of *Arisaema*. Almost half species (ca. 80 species) of *Arisaema* grow in China, particularly in China's eastern Himalayan region. A few species such as *Arisaema flavum* and *A. zhui* can grow at very high altitude over 4,000 meters above sea level. The inflorescence of most *Arisaema* species is extraordinary, and attracted many enthusiasm's interests. They are also traditional herbal medicine used by different ethnic peoples. Some *Arisaema* species become threatened because of over harvest or other human activities.

3. Indigenous aroids as ornamentals in China

Some aroids native to China have been cultivated as ornamentals. *Alocasia odora* is the most popular aroid among all ornamental aroids including exotic species grown in China. The commercial name of *Alocasia odora* is *Dishui Guanyin*, which implies sincerity, common goal or inherent beauty. Therefore, many Chinese people like to grow this aroid for good fortune. In southern China, it can be grown as garden plant or ground cover. In the northern China, it is grown indoors as potted ornamentals, particularly in apartments or houses, lobbies of hotels, restaurants and conference halls.

Native aroid species used as ornamentals in China are from *Alocasia*, *Leucocasia*, *Rhaphidophora*, *Epipremnum*, and *Colocasia*. Among them, *Alocasia macrorhizos*, *Leucocasia gigantea*, and *Rhaphidophora decursiva* are common ornamental species. *Leucocasia gigantea*, formerly *Colocasia gigantea*, is a beautiful and evergreen aroid with huge leaves growing in limestone regions extended to southeast Asia. They are distributed massively and can form small populations in the tropics and southern subtropics of Yunnan, Guangxi, Guangdong, Hainan, Fujian, Jiangxi and Taiwan. It has been cultivated as an ornamental and food plant in Hunan, Guizhou, Sichuan, and its natural habitats.

The ornamental cultivars of taro (*Colocasia esculenta*) have been grown for aesthetic purposes worldwide. In North America (e.g. New York) and Europe, ornamental cultivars of taro are used to decorate streets, gardens and indoors. 'Black Magic', 'Black Runner', 'Black Coral', 'Tropical Storm', and 'White Lava' are famous cultivars. Over 100 cultivars and landraces of taro have been found in China. Mostly they are used as food or industrial materials. A few cultivars are ornamentals, both aquatic and terrestrial.

Many other aroids native to China are very potential for future horticulture and gardens. As shown in Table 2, at least 20 species native to China are with aesthetic values, or have been cultivated as ornamentals. Only 6 species are cultivated in a small scale but the others have often been grown in urban areas. *Rhaphidophora megaphylla* occurring in the tropics is considered as a great garden plant for its broad and beautiful leaves.

In addition to ornamental values, about 50% of Araceae species in China are medicinal plants. Among 20 species listed in Table 2, 16 are traditionally used as herbal medicines by different ethnic groups. Some species of *Amorphophallus* and *Colocasia* are cultivated for food or industrial purposes. According to a statistics of 2010, the cultivation area of *Amorphophallus* in China reached about 40,000 hm^2 and the yield was 200,000t, and the taro cultivation area in China reached 85,210 hm^2 and the yield was 14,580,000t [6].

Table 2

Aroids native to China for ornamental purposes

No.	Genus name	Species name	Frequency	Other uses	Part used
1	*Aglaonema*	*modestum*	★★★★	Herbal medicine	Whole plant
2		*simplex*	★★		
3	*Alocasia*	*cucullata*	★★★★	Green fence, medicine	Whole plant
4		*macrorrhizos*	★★★	Herbal medicine	Rhizome
5		*odora*	★★★★★★	Herbal medicine	Rhizome
6	*Amorphophallus*	*albus*	★	Food	Tuber
7		*paeoniifolius*	★	Herbal medicine	Tuber
8	*Colocasia*	*esculenta*	★★★	Food	Tuber
9	*Epipremnum*	*pinnatum*	★★★	Herbal medicine	Rhizome
10	*Homalomena*	*occulta*	★★	Herbal medicine	Rhizome
11	*Leucocasia*	*gigantea*	★★★★★	Food, medicine	Petiole
12	*Pistia*	*stratiotes*	★★★	Fodder	Whole plant
13	*Remusatia*	*hookeriana*	★	Herbal medicine	Tuber
14		*vivipara*	★	Herbal medicine	Tuber
15	*Rhaphidophora*	*decursiva*	★★★	Herbal medicine	Stem
16		*hongkongensis*	★★	Herbal medicine	Stem
17		*hookeri*	★★	Herbal medicine	Stem
18		*megaphylla*	★★★	Herbal medicine	Stem
19	*Steudnera*	*colocasiifolia*	★	Herbal medicine	Rhizome
20		*griffithii*	★	Herbal medicine	Rhizome

4. Conservation of Chinese aroids

Some wild aroids have been threatened by over harvesting, and other human activities. For example, the wild populations of *Amorphophallus albus*, *Leucocasia gigantea*, and *Rhaphidophora megaphylla* have rapidly decreased in recent 20 years. A few *Arisaema* species cannot be collected from their original habitats. Because of their medicinal values, many *Arisaima* species had been overharvested. The conservation strategies were proposed as follows, based on our field investigation and laboratory studies.

Although the Chinese native *Cryptocoryne* species had been listed in China Red Data Book, the others in the family have been ignored for a long time. They should be evaluated according the IUCN criteria. Then the evaluation results should be adopted in the management of nature reserves and other protection systems.

The way of *ex situ* conservation is essential to preserve the genetic resources of wild plants, especially those threatened in the wild. The methods of plant taxonomy, ethnobotany, seed biology, biotechnology, ecology, molecular biology, and horticulture should be adopted

to investigate germplasm resources, seed vitalities, propagation properties, genetic diversity, growth and development, and others. *Alocasia*, *Amorphophallus*, *Arisaema*, *Colocasia*, *Epipremnum*, *Leucocasia*, *Pinnellia*, *Pothos*, *Remusatia*, *Rhaphidophora* and other genera should be emphasized. Through collection and conservation of genetic resources of wild ornamental aroids, they can be preserved in germplasm banks, including the forms of seeds, *in vitro* materials, DNA and genetic materials. Some of their germplasm resources had been preserved.

Sustainable use is an ultimate way for biodiversity conservation. It can greatly attract public interests and awareness if a species or cultivar has been used sustainably. The aroids with ornamental potentials can be developed as garden or indoor plants. Through tissue culture and other approaches of biotechnology, more seedlings will be produced. Thus the pressure on wild populations will be released.

Conclusions

China becomes one of the biggest consumers of ornamental aroids in the world. Big enterprises have engaged in aesthetic aroid production in recent decades. About 120 species in 14 genera of exotic aroids have been cultivated in China as ornamentals for more than 30 years. The most popular introduced aroids are *Anthurium*, *Epipremnum*, *Spathiphyllum* and *Philodendron*. Other groups such as *Aglaonema*, *Alocasia*, *Dieffenbachia*, *Monstera*, and *Zantedeschia* are commonly grown as garden plants in southern China, and as potted indoor ornamentals in northern China.

China has rich aroid diversity with 181 species in 26 genera. At least 20 aroid species native to China are with aesthetic values, or have been cultivated as ornamentals. *Alocasia odora* is the most popular ornamental aroid growing widely in China. *Leucocasia gigantea* is considered as the most potential ornamental aroid in the country because of its huge leaves and other values.

Some aroid species become rare and endangered. The proposed conservation strategies include *in situ* conservation, *ex situ* conservation (i.e. seed banks and *in vitro* banks), sustainable uses, and entering list of Red Data Book of China. So far *Alocasia*, *Amorphophallus*, *Arisaema*, *Colocasia*, *Cryptocoryne*, *Epipremnum*, *Leucocasia*, *Pinnellia*, *Pothos*, *Remusatia*, *Rhaphidophora* and other genera have been emphasized, and some germplasm resources have been collected and preserved in the germplasm banks.

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Ароидные являются весьма популярными декоративными растениями в Китае. Однако статус их культивирования и потенциал развития все еще слабо изучены. В данном исследовании приведены подходы к их полевому изучению. Результаты свидетельствуют, что около 120 видов экзотического антуриума культивируется в качестве декоративных растений в Китае, таких как *Anthurium*, *Philodendron*, и *Zantedeschia*. В Китае имеется большое биоразнообразие Araceae. Наиболее распространенными природными декративными растениями являются *Alocasia odora* и *Leucocasia gigantea*. Многие другие природные виды антуриума имеют высокий потенциал для будущего садового возделывания в Китае.

Key words: *Alocasia odora*; *Araceae*; *биоразнообразие*; *Китай*; *Leucocasia gigantea*; *декоративные ароидные*.