Redefining *Catalpa*: Exploring Diversity and Breeding Novel Urban Trees©

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INTRODUCTION

Catalpa taxa are generally regarded as hardy, urban-tolerant trees, beautiful in flower and foliage, yet messy in fruit and susceptible to diseases. This dichotomy represents a challenge for plant breeders wishing to broaden the palette of available, low-maintenance, urban-adapted trees. The broad adaptability of catalpa, both in hardiness and abiotic stress tolerances, provides ample opportunity to develop novel cultivars for the urban landscape. The opportunity to develop improved forms of catalpa presented itself during the course of my doctoral research investigating the reproductive biology, ploidy manipulation, and fertility restoration in the bi-generic hybrid ×*Chitalpa* (*Catalpa bignonioides* × *Chilopsis linearis*) while at North Carolina State University (NCSU) under the direction of Dr. Thomas G. Ranney (Olsen et al., 2006b). It was quickly realized that to breed improved ×*Chitalpa* cultivars, the ideal catalpa must first be identified and developed. In 2006, this project became a collaborative effort between NCSU and the U.S. National Arboretum (USNA). The development of a systematic *Catalpa* breeding program would result in the development of disease and pest tolerant, sterile, urban trees for USDA Hardiness Zones 4–9, an area that encompasses most of the lower 48 states.

TAXONOMY

The genus *Catalpa* (Bignoniaceae) is composed of 11 species in two well-defined sections, *Catalpa* and *Macrocatalpa* (Palct, 1952). Section *Catalpa* contains six species of deciduous trees with a disjunct distribution between East Asia (four species) and eastern North America (two species). The two N. American species, *C. bignonioides* and *C. speciosa*, are frequently cultivated and widely naturalized in urban areas of the eastern United States (Rehder, 1940). The broad climatic and edaphic adaptability warrants increase planting of *Catalpa* species in urban forests (Koller and Dirr, 1979). While the North American species are well known, the Asian and West Indian (sect. *Macrocatalpa*) species are not. Of the four species of Asian *Catalpa* currently recognized (*C. bungei, C. fargesii, C. ovata,* and *C. tibetica*), all but *C. tibetica* are known in cultivation. Trueness-to-type was questioned by Olsen et al. (2006a) for several accessions of *Catalpa bungei* collected from various botanical institutions, which were ultimately identified as two different species and two unidentified hybrids. Likewise, *C. fargesii* (including *C. fargesii* f. *duclouxii*) is confused in both the U.S. and European nursery trade, with only one plant in the U.S. matching the type description. Dr. Joseph H. Kirkbride, Jr. (USNA, taxonomist) is investigating the taxonomy of *Catalpa* to determine correct species delimitations within the *Catalpa bungei-fargesii* complex. The groundwork is also being laid for a USNA expedition to China to increase wild collections of Asian *Catalpa,* especially *C. tibetica.*

POWDERY MILDEW AND CATALPA SPHINX STUDIES

Use of *Catalpa* sp. in the urban forests and landscapes is tempered, in part, by their susceptibility to powdery mildew (*Erysiphe elevata*) and defoliation by catalpa sphinx moth larvae (*Ceratomia catalpae*). Olsen et al. (2006a) evaluated 24 taxa of *Catalpa*, *Chilopsis,* and the bi-generic hybrid, ×*Chitalpa*, for susceptibility to *E. elevata* and *C. catalpae.* Plants were grown in containers and evaluated in 50% shade (Year 1) and full sun (Year 2) and subjected to natural inoculations supplemented with inocula from heavily infected *C. bignonioides* stock plants. Two sources of resistance to *E. elevata* were discovered: east Asian species in sect. *Catalpa* (*C. bungei, C. fargesii* var. *duclouxii,* and *C. ovata*) and West Indian species in sect. *Macrocatalpa* (*C. longissima*, and *C. punctata*). Cook et al. (2006) observed severe *E. elevata* infections on North American *Catalpa* species in England, and, as in the above study, found the Asian species (*C. bungei, C. fargesii,* and *C. ovata*) uninfected by either *E. elevata* or a second powdery mildew, *Neoerysiphe galeopsidis*. Interspecific *Catalpa* hybrids between North American and Asian species show intermediate levels of susceptibility, indicating partial transmission of resistance to *E. elevata* (Olsen et al., 2006a). The mechanism of resistance and the mode of inheritance are unknown, but are important in developing a breeding program for genetic improvement of *Catalpa* and ×*Chitalpa.* Leaf disk assays for elucidating mechanisms of resistance in *Catalpa* germplasm and quantifying susceptibility in intergeneric and interspecific hybrids will be developed.

A no-choice feeding study conducted using leaf tissue harvested from the above plants (Year 2) found no differences in survival or growth of *C. catalpae* larvae reared on taxa from both sections of *Catalpa*, *Chilopsis,* and ×*Chitalpa.* Future breeding of ×*Chitalpa* can utilize the two different, known sources of powdery mildew resistance, but an immediate source for resistance to catalpa sphinx moth was not identified. In 2006, the collection of *Catalpa* and related taxa from Olsen et al. (2006a) was duplicated and supplemented with newly acquired germplasm at the USNA (Table 1).

CROSSABILITY STUDIES

Catalpa speciosa and *C. linearis* are considered self-incompatible (Petersen et al., 1982; Stephenson and Thomas, 1977). However, preliminary crossing experiments indicate that *C. ovata* is self-fertile, and this trait is inherited in interspecific hybrids with *C. bignonioides* and *C. speciosa*. Other species of *Catalpa* have not been tested however. Identification and inheritance of self-compatibility are critical data necessary for screening progeny reduced fruit set and limiting invasive potential of *Catalpa.* Although hybrids between the Chinese *C. ovata* and N. American *C. bignonioides* and *C. speciosa* exist (*C.* ×*erubescens* and *C.* ×*galleana*, respectively), no hybrids are known involving the *C. bungei-fargesii* complex. Furthermore, there are no known intersectional hybrids (sect. *Catalpa* and sect. *Macrocatalpa*), yet intergeneric hybrids between *C. linearis* and *C. speciosa* and *C. bignonioides* exist (Li et al., 2006). Our extensive collection of *Catalpa* and related germplasm will be used for investigating intersectional crossing within *Catalpa* and intergeneric crosses with *Chilopsis.*

To fully investigate interspecific and intergeneric crosses basic knowledge of genome sizes and ploidy differences is crucial to understanding successes or failures. This knowledge is also crucial for the development of sterile triploid progeny

Table 1. Taxa of *Catalpa*, *Chilopsis,* and ×*Chitalpa* in the urban tree breeding research collection at the U.S. National Arboretum, irrespective of taxonomic standing.

Catalpa bignonioides	
"	'Aurea'
"	'Aurea Nana'
"	'Koehnei'
"	'Nana'
"	'Variegata'
Catalpa bungei	
Catalpa ×*erubescens*	
"	'Japonica'
"	'J.C. Teas'
"	'Purpurea'
Catalpa fargesii	
"	'Ecos'
"	f. *duclouxii*
Catalpa ×*galleana*	
Catalpa longissima	
Catalpa ovata	
"	'Flavescens'
"	'Slender Silhouette'
Catalpa punctata	
Catalpa speciosa	
"	'Frederik'
"	USNA witch's broom
Catalpa szechuanica	
Chilopsis linearis	'Art's Pride'
"	'Bubba'
"	'Burgundy' (syn. 'Burgundy Lace')
"	'Compact White'
"	'Dark Storm'
"	'Lucretia Hamilton'
"	'Monhews', Timeless Beauty™ desert willow
"	'Warren Jones'
×*Chitalpa tashkentensis* 'Pink Dawn'	
"	'Minsum'
"	'Morning Cloud'

through inter-ploid crosses. Induction of polypoids of woody ornamental genera using mitotic inhibitors (e.g., colchicine and oryzalin) has been shown to be efficient and rapid with intact apical meristems of ×*Chitalpa* (Olsen et al., 2006b) For genera where no known ploidy-series exist (i.e., *Catalpa*), the manipulation of ploidy level, and the development of polyploids, allows for the production of interploids with reduced fertility for deployment as non-invasive nursery crops.

SUMMARY

The genus *Catalpa* contains overlooked species available for increasing the diversity of urban forests. Better yet, there is untapped genetic diversity within and between species, and closely related genera, to form the foundation for a systematic breeding program. For today's market, improved catalpa cultivars can meet both the need for extended ornamental appeal, as well as disease, pest, and urban tolerances. Taxonomic studies are underway to elucidate species relationships and clarify confusion in cultivated taxa. Crossing studies have begun to elucidate interspecific, intersectional, and intergeneric crossing barriers between *Catalpa* and *Chilopsis* and the resultant hybrids, ×*Chitalpa*, to incorporate powdery mildew resistance as well as other ornamental traits.

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