

**ASSESSMENT OF THE HAMAMELIDACEAE IN GLOBAL LIVING  
COLLECTIONS**

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Science in Plant and Soil Sciences

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## TABLE OF CONTENTS

LIST OF TABLES .....	x
LIST OF FIGURES .....	xv
ABSTRACT .....	xvi

### Chapter

1	INTRODUCTION .....	1
	1.1 Materials and Methods .....	1
	1.2 Family Description .....	9
2	SPECIES DESCRIPTIONS .....	14
	2.1 <i>Chunia</i> Overview .....	14
	2.1.1 <i>Chunia bucklandioides</i> H.T. Chang .....	14
	2.2 <i>Corylopsis</i> Overview .....	17
	2.2.1 <i>Corylopsis alnifolia</i> (H.Lév.) C.K.Schneid. ....	20
	2.2.2 <i>Corylopsis brevistyla</i> H.T.Chang .....	22
	2.2.3 <i>Corylopsis calicola</i> C.Y. Wu.....	24
	2.2.4 <i>Corylopsis coreana</i> Uyeki .....	24
	2.2.5 <i>Corylopsis glabrescens</i> Franch. & Sav .....	26
	2.2.6 <i>Corylopsis glandulifera</i> Hemsl.....	28
	2.2.7 <i>Corylopsis glaucescens</i> Hand.-Mazz.....	30
	2.2.8 <i>Corylopsis gotoana</i> Makino .....	32
	2.2.9 <i>Corylopsis henryi</i> Hemsl. ....	33
	2.2.10 <i>Corylopsis himalayana</i> Griff. ....	35
	2.2.10.1 <i>Corylopsis himalayana</i> var. <i>griffithii</i> (Hemsl.) B.D. Morley & J.M. Chao.....	37
	2.2.11 <i>Corylopsis microcarpa</i> H.T.Chang .....	38
	2.2.12 <i>Corylopsis multiflora</i> Hance.....	39
	2.2.12.1 <i>Corylopsis multiflora</i> var. <i>multiflora</i> Hance .....	41
	2.2.12.2 <i>Corylopsis multiflora</i> var. <i>nivea</i> H.T. Chang .....	42
	2.2.13 <i>Corylopsis obovata</i> H.T.Chang .....	42
	2.2.14 <i>Corylopsis omeiensis</i> W.C. Cheng .....	43
	2.2.15 <i>Corylopsis pauciflora</i> Siebold & Zucc.....	45

2.2.16	<i>Corylopsis platypetala</i> Rehder & E.H.Wilson .....	47
2.2.17	<i>Corylopsis rotundifolia</i> H.T.Chang.....	49
2.2.18	<i>Corylopsis sinensis</i> Hemsl.....	51
2.2.19	<i>Corylopsis spicata</i> Siebold & Zucc.....	54
2.2.20	<i>Corylopsis stelligara</i> Guillaumin .....	56
2.2.21	<i>Corylopsis trabeculosa</i> Hu & W.C.Cheng .....	57
2.2.22	<i>Corylopsis veitchiana</i> Bean.....	59
2.2.23	<i>Corylopsis velutina</i> Hand.-Mazz.....	61
2.2.24	<i>Corylopsis willmottiae</i> Rehder & E.H.Wilson .....	63
2.2.25	<i>Corylopsis yui</i> Hu & W.C.Cheng.....	65
2.2.26	<i>Corylopsis yunnanensis</i> Diels.....	66
2.2.27	<i>Corylopsis</i> Cultivars .....	68
2.3	<i>Dicoryphe</i> Overview .....	69
2.3.1	<i>Dicoryphe angustifolia</i> Tul.....	70
2.3.2	<i>Dicoryphe buddleoides</i> Baker .....	71
2.3.3	<i>Dicoryphe gracilis</i> Tul. ....	72
2.3.4	<i>Dicoryphe guatteriifolia</i> Baker.....	72
2.3.5	<i>Dicoryphe lanceolata</i> Tul.....	73
2.3.6	<i>Dicoryphe laurifolia</i> Baker.....	73
2.3.7	<i>Dicoryphe laurina</i> Baill.....	74
2.3.8	<i>Dicoryphe macrophylla</i> Baill. ....	75
2.3.9	<i>Dicoryphe noronhae</i> Tul. ....	76
2.3.10	<i>Dicoryphe platyphylla</i> Tul.....	77
2.3.11	<i>Dicoryphe retusa</i> Baker.....	78
2.3.12	<i>Dicoryphe stipulacea</i> J. St.-Hil. ....	79
2.3.13	<i>Dicoryphe viticoides</i> Baker .....	79
2.4	<i>Disanthus</i> Overview .....	81
2.4.1	<i>Disanthus cercidifolius</i> .....	81
2.4.1.1	<i>Disanthus cercidifolius</i> subsp. <i>longipes</i> (H.T. Chang) K.Y. Pan .....	84
2.4.2	<i>Disanthus ovatifolius</i> Averyanov et al. ....	86
2.4.3	<i>Disanthus</i> Cultivars .....	90
2.5	<i>Distyliopsis</i> Overview .....	91
2.5.1	<i>Distyliopsis dunnii</i> (J.H. Hemsl.) Endress.....	93
2.5.2	<i>Distyliopsis lanata</i> N.A. Brummitt & Utteridge .....	94
2.5.3	<i>Distyliopsis laurifolia</i> (J.H. Hemsl.) Endress .....	96

2.5.4	<i>Distyliopsis salicifolia</i> (H.L. Li & E. Walker) Endress.....	98
2.5.5	<i>Distyliopsis tutcheri</i> (J.H. Hemsl.) Endress.....	99
2.5.6	<i>Distyliopsis yunnanensis</i> (H.T.Chang) C.Y. Wu.....	101
2.6	<i>Distylium</i> Overview .....	102
2.6.1	<i>Distylium annamicum</i> (Gagnep.) A. Shaw .....	106
2.6.2	<i>Distylium buxifolium</i> (Hance) Merr.....	107
2.6.3	<i>Distylium chinense</i> (Fr. ex Hemsl.) Diels.....	109
2.6.4	<i>Distylium chungii</i> (Metcalf) W.C. Cheng.....	111
2.6.5	<i>Distylium dunnianum</i> H. Lév. ....	112
2.6.6	<i>Distylium elaeagnoides</i> H.T. Chang.....	113
2.6.7	<i>Distylium gracile</i> Nakai.....	115
2.6.8	<i>Distylium indicum</i> Benth. ex C.B. Clarke .....	116
2.6.9	<i>Distylium lepidotum</i> Nakai .....	117
2.6.10	<i>Distylium macrophyllum</i> H.T. Chang.....	119
2.6.11	<i>Distylium myricoides</i> Hemsl.....	120
2.6.12	<i>Distylium pingpienense</i> (Hu) E. Walker.....	123
2.6.13	<i>Distylium racemosum</i> Siebold. & Zucc.....	125
2.6.14	<i>Distylium tsiangii</i> Chun ex Walker .....	128
2.6.15	<i>Distylium stellare</i> Kuntze .....	129
2.6.16	<i>Distylium</i> Cultivars .....	130
2.7	<i>Embolanthera</i> Overview here.....	131
2.7.1	<i>Embolanthera glabrescens</i> H.L. Li .....	132
2.7.2	<i>Embolanthera spicata</i> Merr.....	133
2.8	<i>Eustigma</i> Overview .....	135
2.8.1	<i>Eustigma balansae</i> Oliv. ....	137
2.8.2	<i>Eustigma honbaense</i> H.Toyama, Tagane & V.S.Dang .....	138
2.8.3	<i>Eustigma lenticillatum</i> C.Y.Wu .....	141
2.8.4	<i>Eustigma oblongifolium</i> Gardner & Champ.....	142
2.9	<i>Exbucklandia</i> Overview .....	144
2.9.1	<i>Exbucklandia longipetala</i> H.T. Chang .....	146
2.9.2	<i>Exbucklandia populnea</i> (R. Brown ex Griffith) R. W. Brown..	148
2.9.3	<i>Exbucklandia stellatum</i> .....	152
2.9.4	<i>Exbucklandia tonkinensis</i> (Lecomte) H. T. Chang.....	152
2.10	<i>Fortunearia</i> Overview .....	155

2.10.1	<i>Fortunearia sinensis</i> Rehd. et Wils. ....	156
2.11	<i>Fothergilla</i> Overview .....	159
2.11.1	<i>Fothergilla gardenii</i> Murray .....	163
2.11.2	<i>Fothergilla major</i> G.Lodd. ....	166
2.11.3	<i>Fothergilla</i> × <i>intermedia</i> Ranney & Fantz.....	170
2.11.4	<i>Fothergilla</i> Cultivars .....	171
2.12	Hamamelis Overview .....	173
2.12.1	<i>Hamamelis japonica</i> Siebold & Zucc.....	174
2.12.2	<i>Hamamelis mexicana</i> Standl. ....	174
2.12.3	<i>Hamamelis mollis</i> Oliv. ex F.B.Forbes & Hemsl.....	175
2.12.4	<i>Hamamelis ovalis</i> S.W.Leonard .....	175
2.12.5	<i>Hamamelis vernalis</i> Sarg.....	176
2.12.6	<i>Hamamelis virginiana</i> L.....	176
2.12.7	<i>Hamamelis</i> × <i>intermedia</i> Rehder.....	177
2.13	<i>Loropetalum</i> Overview.....	178
2.13.1	<i>Loropetalum chinense</i> (R. Br.) Oliv .....	180
2.13.1.1	<i>Loropetalum chinense</i> (R. Br.) Oliv. var. <i>chinense</i> ....	184
2.13.1.2	<i>Loropetalum chinense</i> var. <i>coloratum</i> C.Q. Huang....	185
2.13.1.3	<i>Loropetalum chinense</i> var. <i>rubrum</i> Yieh.....	185
2.13.2	<i>Loropetalum lanceum</i> Hand.-Mazz.....	186
2.13.3	<i>Loropetalum subcordatum</i> (Benth.) Oliver .....	187
2.13.4	<i>Loropetalum</i> Cultivars.....	191
2.14	<i>Maingaya</i> Overview .....	194
2.14.1	<i>Maingaya malayana</i> Oliv. ....	196
2.15	<i>Matudaea</i> Overview .....	198
2.15.1	<i>Matudaea colombiana</i> Lozano .....	199
2.15.2	<i>Matudaea trinervia</i> Lundell .....	200
2.16	<i>Molinadendron</i> Overview .....	202
2.16.1	<i>Molinadendron guatemalense</i> (Radlk. Ex Harms) P.K. Endress .....	203
2.16.2	<i>Molinadendron hondurense</i> (Standl.) P.K. Endress.....	204

2.16.3	<i>Molinadendron sinoloanse</i> (Standl. & Gentry) P.K. Endress ...	205
2.17	<i>Mytilaria</i> Overview .....	206
2.17.1	<i>Mytilaria laosensis</i> Lec. ....	206
2.18	<i>Neostrearia</i> Overview .....	209
2.18.1	<i>Neostrearia fleckeri</i> L.S.Sm. ....	209
2.19	<i>Noahdendron</i> Overview .....	211
2.19.1	<i>Noahdendron nicholasii</i> P.K. Endress, B.Hyland & Tracey .....	211
2.20	<i>Ostrearia</i> Overview .....	213
2.20.1	<i>Ostrearia australiana</i> Baill. ....	214
2.21	<i>Parrotia</i> Overview.....	215
2.21.1	<i>Parrotia subaequalis</i> (H.T. Chang) R.M. Hao et H.T. Wei .....	216
2.21.2	<i>Parrotia persica</i> (DC) C.A. Mey .....	219
2.21.3	<i>Parrotia</i> Cultivars.....	222
2.22	<i>Parrotiopsis</i> Overview .....	224
2.22.1	<i>Parrotiopsis jacquemontiana</i> (Decne) Rehder .....	224
2.23	<i>Rhodoleia</i> Overview .....	227
2.23.1	<i>Rhodoleia championii</i> Hook. f. ....	229
2.23.2	<i>Rhodoleia forrestii</i> Chun ex Exell .....	235
2.23.3	<i>Rhodoleia henryi</i> Tong .....	238
2.23.4	<i>Rhodoleia macrocarpa</i> H.T. Chang .....	241
2.23.5	<i>Rhodoleia parvipetala</i> K.Y. Tong .....	243
2.23.6	<i>Rhodoleia stenopetala</i> H.T. Chang .....	245
2.23.7	<i>Rhodoleia</i> Cultivars .....	248
2.24	<i>Sinowilsonia</i> Overview.....	248
2.24.1	<i>Sinowilsonia henryi</i> Hemsl.....	249
2.24.1.1	<i>Sinowilsonia henryi</i> var. <i>henryi</i> .....	253
2.24.1.2	<i>Sinowilsonia henryi</i> var. <i>glabrescens</i> .....	253



2.25	<i>Sycopsis</i> Overview.....	254
2.25.1	<i>Sycopsis griffithiana</i> Oliv.....	256
2.25.2	<i>Sycopsis sinensis</i> Oliv.....	257
2.25.3	<i>Sycopsis triplinervia</i> H.T. Chang .....	260
2.25.4	<i>Sycopsis</i> Cultivars.....	261
2.26	× <i>Sycoparrotia</i> Overview.....	262
2.26.1	× <i>Sycoparrotia</i> Cultivars .....	264
2.26.1.1	× <i>Sycoparrotia semidecidua</i> ‘Purple Haze’ .....	264
2.26.1.2	× <i>Sycoparrotia semidecidua</i> ‘Variegata’ .....	264
2.26.1.3	× <i>Sycoparrotia semidecidua</i> ‘Prins Claus’ .....	265
2.26.1.4	× <i>Sycoparrotia semidecidua</i> ‘Autunno Rosso’ .....	266
2.27	<i>Trichocladus</i> Overview .....	266
2.27.1	<i>Trichocladus crinitus</i> Pers.....	267
2.27.2	<i>Trichocladus ellipticus</i> Eckl. & Zeyh.....	268
2.27.3	<i>Trichocladus goetzei</i> Engl.....	270
2.27.4	<i>Trichocladus grandiflorus</i> Oliv.....	270
3	ASSESSMENT OF LIVING COLLECTIONS .....	272
3.1	BGCI Institution Report .....	273
3.2	BGCI Collections Survey .....	277
3.3	Analysis of BGCI Data Sets .....	283
3.3.1	Data Set Comparison.....	284
3.3.2	Combined Data Sets and Conservation Status .....	291
3.3.3	Discussion.....	297
	REFERENCES .....	299
	Appendices .....	315
A	HAMAMELIDACEAE CULTIVAR CHECK LIST (EXCLUDING <i>HAMAMELIS</i> ) .....	328
B	BGCI INSTITUTION REPORT: TAXA BY COUNTRY AND INSTITUTION.....	346
C	BGCI COLLECTIONS SURVEY: ACCESSION STATISTICS.....	359
D	BGCI COLLECTIONS SURVEY: PLANTS LEVEL DATA .....	361
E	<i>HAMAMELIS</i> RESOURCES.....	363

## LIST OF TABLES

Table 1 <i>Chunia bucklandioides</i> : BGCi Institution Report and BGCi Collections Survey.....	17
Table 2 <i>Corylopsis alnifolia</i> : BGCi Institution Report and BGCi Collections Survey.....	22
Table 3 <i>Corylopsis coreana</i> : BGCi Institution Report and BGCi Collections Survey.....	25
Table 4 <i>Corylopsis glabrescens</i> : BGCi Institution Report and BGCi Collections Survey.....	28
Table 5 <i>Corylopsis glandulifera</i> : BGCi Institution Report and BGCi Collections Survey.....	30
Table 6 <i>Corylopsis gotoana</i> : BGCi Institution Report and BGCi Collections Survey.....	33
Table 7 <i>Corylopsis henryi</i> : BGCi Institution Report and BGCi Collections Survey...	35
Table 8 <i>Corylopsis himalayana</i> : BGCi Institution Report and BGCi Collections Survey.....	37
Table 9 <i>Corylopsis multiflora</i> : BGCi Institution Report and BGCi Collections Survey.....	40
Table 10 <i>Corylopsis pauciflora</i> : BGCi Institution Report and BGCi Collections Survey.....	47
Table 11 <i>Corylopsis platypetala</i> : BGCi Institution Report and BGCi Collections Survey.....	49
Table 12 <i>Corylopsis sinensis</i> : BGCi Institution Report and BGCi Collections Survey.....	53
Table 13 <i>Corylopsis spicata</i> : BGCi Institution Report and BGCi Collections Survey.....	55
Table 14 <i>Corylopsis trabeculosa</i> : BGCi Institution Report and BGCi Collections Survey.....	59
Table 15 <i>Corylopsis veitchiana</i> : BGCi Institution Report and BGCi Collections Survey.....	61

Table 16 <i>Corylopsis willmottiae</i> : BGCI Institution Report and BGCI Collections Survey.....	65
Table 17 <i>Disanthus cercidifolius</i> : BGCI Institution Report and BGCI Collections Survey.....	84
Table 18 <i>Disanthus cercidifolius</i> var. <i>longipes</i> : BGCI Institution Report and BGCI Collections Survey .....	86
Table 19 <i>Disanthus ovatifolius</i> : BGCI Institution Report and BGCI Collections Survey.....	90
Table 20 <i>Distyliopsis tutcheri</i> : BGCI Institution Report and BGCI Collections Survey.....	100
Table 21 <i>Distyliopsis yunnanensis</i> : BGCI Institution Report and BGCI Collections Survey.....	102
Table 22 <i>Distylium</i> sp.: BGCI Institution Report and BGCI Collections Survey .....	106
Table 23 <i>Distylium buxifolium</i> : BGCI Institution Report and BGCI Collections Survey.....	108
Table 24 <i>Distylium chinense</i> : BGCI Institution Report and BGCI Collections Survey.....	111
Table 25 <i>Distylium elaeagnoides</i> : BGCI Institution Report and BGCI Collections Survey.....	115
Table 26 <i>Distylium lepidotum</i> : BGCI Institution Report and BGCI Collections Survey.....	119
Table 27 <i>Distylium myricoides</i> : BGCI Institution Report and BGCI Collections Survey.....	123
Table 28 <i>Distylium racemosum</i> : BGCI Institution Report and BGCI Collections Survey.....	128
Table 29 <i>Eustigma oblongifolium</i> : BGCI Institution Report and BGCI Collections Survey.....	144
Table 30 <i>Exbucklandia populnea</i> : BGCI Institution Report and BGCI Collections Survey.....	152

Table 31 <i>Exbucklandia populnea</i> : BGC I Institution Report and BGC I Collections Survey.....	155
Table 32 <i>Fortunearia sinensis</i> : BGC I Institution Report and BGC I Collections Survey.....	159
Table 33 <i>Fothergilla</i> sp.: BGC I Institution Report and BGC I Collections Survey ...	163
Table 34 <i>Fothergilla gardenii</i> : BGC I Institution Report and BGC I Collections Survey.....	166
Table 35 <i>Fothergilla major</i> : BGC I Institution Report and BGC I Collections Survey.....	169
Table 36 <i>Fothergilla</i> × <i>intermedia</i> : BGC I Institution Report and BGC I Collections Survey.....	171
Table 37 <i>Hamamelis</i> sp.: BGC I Institution Report and BGC I Collections Survey ...	173
Table 38 <i>Hamamelis japonica</i> : BGC I Institution Report and BGC I Collections Survey.....	174
Table 39 <i>Hamamelis mexicana</i> : BGC I Institution Report and BGC I Collections Survey.....	174
Table 40 <i>Hamamelis mollis</i> : BGC I Institution Report and BGC I Collections Survey.....	175
Table 41 <i>Hamamelis ovalis</i> : BGC I Institution Report and BGC I Collections Survey.....	176
Table 42 <i>Hamamelis vernalis</i> : BGC I Institution Report and BGC I Collections Survey.....	176
Table 43 <i>Hamamelis virginiana</i> : BGC I Institution Report and BGC I Collections Survey.....	177
Table 44 <i>Hamamelis</i> × <i>intermedia</i> : BGC I Institution Report and BGC I Collections Survey.....	177
Table 45 <i>Loropetalum chinense</i> : BGC I Institution Report and BGC I Collections Survey.....	184
Table 46 <i>Loropetalum subcordatum</i> : BGC I Institution Report and BGC I Collections Survey .....	191

Table 47 <i>Maingaya malayana</i> : BGCI Institution Report and BGCI Collections Survey.....	197
Table 48 <i>Matudaea trinervia</i> : BGCI Institution Report and BGCI Collections Survey.....	202
Table 49 <i>Molinadendron sinoloanse</i> : BGCI Institution Report and BGCI Collections Survey .....	205
Table 50 <i>Mytilaria laosensis</i> : BGCI Institution Report and BGCI Collections Survey.....	209
Table 51 <i>Neostrearia fleckeri</i> : BGCI Institution Report and BGCI Collections Survey.....	211
Table 52 <i>Noahdendron nicholasii</i> : BGCI Institution Report and BGCI Collections Survey.....	213
Table 53 <i>Ostrearia australiana</i> : BGCI Institution Report and BGCI Collections Survey.....	215
Table 54 <i>Parrotia subaequalis</i> : BGCI Institution Report and BGCI Collections Survey.....	219
Table 55 <i>Parrotia persica</i> : BGCI Institution Report and BGCI Collections Survey.....	221
Table 56 <i>Parrotiopsis jacquemontiana</i> : BGCI Institution Report and BGCI Collections Survey .....	227
Table 57 <i>Rhodoleia championii</i> : BGCI Institution Report and BGCI Collections Survey.....	235
Table 58 <i>Rhodoleia forrestii</i> : BGCI Institution Report and BGCI Collections Survey.....	238
Table 59 <i>Rhodoleia henryi</i> : BGCI Institution Report and BGCI Collections Survey.....	241
Table 60 <i>Rhodoleia parvipetala</i> : BGCI Institution Report and BGCI Collections Survey.....	245
Table 61 <i>Sinowilsonia henryi</i> : BGCI Institution Report and BGCI Collections Survey.....	253
Table 62 <i>Sycopsis sinensis</i> : BGCI Institution Report and BGCI Collections Survey.....	260

Table 63 × <i>Sycoparrotia semidecdua</i> : BGCI Institution Report and BGCI Collections Survey .....	263
Table 64 <i>Trichocladus crinitus</i> : BGCI Institution Report and BGCI Collections Survey.....	268
Table 65 <i>Trichocladus ellipticus</i> : BGCI Institution Report and BGCI Collections Survey.....	269
Table 66 <i>Trichocladus grandiflorus</i> : BGCI Institution Report and BGCI Collections Survey .....	271
Table 67 BGCI Institution Report Number of Institutions Reporting each Taxon ....	274
Table 68 BGCI Collections Survey: Taxa Reported by Each Institution.....	278
Table 69 BGCI Collections Survey: Genus statistics.....	283
Table 70 BGCI Collections Survey: Taxa most reported by institution .....	285
Table 71 BGCI Institution Report: Taxa most reported by institution.....	285
Table 72 BGCI Collections Survey: Taxa least reported by institution.....	287
Table 73 BGCI Institution Report: Taxa least reported by institution .....	288
Table 74 Hamamelidaceae listed by the IUCN Red List .....	292
Table 75 Hamamelidaceae on IUCN Red List vs. Provenance.....	294

## LIST OF FIGURES

Figure 1 Taxonomic Relationships within the Hamamelidaceae .....	13
Figure 2 BGCI Collections Survey: Most Prevalent Genera by Accession .....	282

## ABSTRACT

“The great breadth of living collections is part of our cultural heritage. No one institution has the entire range of collection types or is ever likely to. This diversity among institutions and their collections is a societal strength-especially as collections are joined in working” (Rakow, Lee, & Raven, 2011). This statement describes the importance of thinking beyond individual garden collections to achieve a greater impact. Regular analysis of a sub-group of plant taxa in this context of representation in regional or global collections allows for a more robust assessment of that specified taxa. Whereas individual arboreta and botanic gardens ensure their collections meet the goals of their Living Collections Policies, networks such as the Plant Collections Network (previously called the National Accredited Plant Collections Consortium), or the Botanic Gardens Conservation International ensure that plant groups are represented with depth amongst a network of arboreta and botanic gardens (Rakow et al., 2011).

For this investigation the subgroup chosen for assessment was the Hamamelidaceae. The goals of this thesis were to (1) reconcile the nomenclature and taxonomy for the family, (2) research and summarize descriptions for each species, (3) note local and global conservation concerns, (4) assess what members of the Hamamelidaceae are in living collections, and (5) create a cultivar checklist for the family. This research provides institutions with an evaluation of the current state of the Hamamelidaceae in global living collections, and can be used to determine if certain taxa should be targeted for inclusion in individual or joint living collections strategies that ultimately aid in *ex situ* conservation.



## Chapter 1

### INTRODUCTION

#### 1.1 Materials and Methods

The first decision with any thesis is to establish the subject of research and the constraints of the project. The subject of this thesis ultimately was decided to be the Hamamelidaceae, but it is important to review why this family was chosen. This thesis was a two-year research project and required that any plant group chosen for this project was an appropriate size for this time constraint. With 140 maximum number of species cited in the literature the family was appropriately scaled. In order to adequately review a plant group for this thesis it needed to have members that were included in living collections, specifically collections that could be accessed with the resources of the University of Delaware. Both the University of Delaware Botanic Gardens and the nearby Morris Arboretum have excellent representation of the family in their temperate collections. The selected plant group also needed to have horticultural interest, but still have members that needed further research. The Hamamelidaceae has many genera that are popular for their horticultural merits such as *Fothergilla*, *Hamamelis*, *Loropetalum*, *Parrotia*, and *Disanthus*, but many genera are practically unknown in cultivation and could have potential to be included in collections.

Finally, the selected plant group needed to included members that possessed named cultivars, as cultivars are an asset horticulturally but are often confused in the

literature when there is no registration authority. The Hamamelidaceae has genera with named cultivars, but only one cultivar registration authority for the genus *Hamamelis*. Choosing the Hamamelidaceae as the focus of this project provides missing information for members of this ornamentally valuable family and highlights lesser known species. As with all theses this thesis is a stepping-stone in scientific endeavors and is meant to consolidate previous research on the family and connect it with future research endeavors.

To understand the state of the Hamamelidaceae in global living collections, three strategies were implemented. These strategies were: to summarize species descriptions for every species in the family, create a cultivar checklist for the family, and to assess what taxa are presently represented in living collections world-wide. Providing species descriptions for this family included verifying accepted nomenclature and ensures that the names discussed in the living collections review are being treated appropriately. As the Hamamelidaceae is a family with many members of ornamental merit a cultivar checklist also helps to ensure the nomenclature is appropriate when reviewing the collections data.

It should be noted that although this thesis is a comprehensive assessment of the family, the genus *Hamamelis* was purposefully excluded from this thesis. This is due to the great attention given to the genus *Hamamelis* within the Hamamelidaceae. Appendix E is a cursory list of the numerous resources available on *Hamamelis*. The resources cover propagation, evolutionary divergence, chemical compounds in the leaves and bark, horticultural value, the biochemical responses of bloom time, the homeopathic uses for the extract, and the ornamental merits of the genus including its numerous cultivars. For these reasons, this assessment of the Hamamelidaceae will

purposely exclude *Hamamelis* from the research and focus on the remaining genera. A list of accepted species of *Hamamelis* is included under the *Species Descriptions* section of this thesis.

The Hamamelidaceae is a family of temperate and subtropical woody plants, centered primarily in Asia and its genera are native to all continents except Europe and Antarctica. With such a large geographic distribution, invariably the taxonomic consensus and state of literature will not always be consistent. This supports the need for the first goal of this thesis; compile species descriptions for all species based on a summary of the literature.

The literature for some taxa, particularly those in cultivation, is readily available, but for non-cultivated or recently described taxa resources were more limited. Taxonomic literature referenced for species descriptions included *The Plant List 1.1*, published September 2013, as the backbone for taxa in the family. *The Plant List 1.1* is a collaborative initiative between the *Royal Botanic Gardens, Kew* (London, England), and the *Missouri Botanical Garden* (St. Louis, Missouri, United States) (The Plant List 1.1, n.d.). The checklists of these institutions, in combination with other collaborators, is combined and run through an algorithm that minimizes conflicts with the datasets (The Plant List 1.1, n.d.). The product is a comprehensive checklist that standardizes nomenclature, and links synonymous plant names. With over 642 families and 17, 020 genera, *The Plant List 1.1* was a valuable tool to create the species descriptions (The Plant List 1.1, n.d.). However, *The Plant List 1.1* is not a perfect tool, as 22% of their records are unresolved, and more recently published resources contained more up-to-date information on the relationships within the family and validity of naming conventions (The Plant List 1.1, n.d.).

The *Flora of China* was used extensively for species descriptions as the family is centered in Asia. Additional sources include publications by Linn Bogle, Susanna Magallón, and Peter Endress. These provided the foundation for both the taxonomic relationships and morphological characteristics. The University of Delaware Botanic Gardens collection was used extensively for personal observations, and in some instances, verification of characteristics. Additional institutions visited to observe live specimens were the JC Raulston Arboretum, The Morris Arboretum, and Longwood Gardens. The decision to observe these collections was based on proximity and presence of Hamamelidaceae taxa within their collections.

Not all material was able to be observed as living material, particularly the subtropical materials, or materials that are rare in cultivation. Where possible, digitized herbarium vouchers were observed in lieu of living material. The Steere Herbarium of New York Botanic Garden, the Botany Collections of the Smithsonian National Museum of Natural History, and the Harvard University Herbaria and Libraries were the main herbarium resources used. To cite herbarium specimens the collector last name was listed first followed by: the date of collection (as recorded by the institution), name of taxon, institutional accession number, institution, and website address where the specimen was retrieved. In text, citations list the collector last name, institution accession number, and the date of collection. Where possible, the collector number is noted within the text.

Observing these resources provided information on physical characteristics, habitat types, and nomenclature history. The template provided by *The Plant List 1.1*, combined with taxonomic research, and physical observations allowed for the creation of the comprehensive species descriptions included in this thesis. Conservation

concern for each species was also researched. This was completed primarily referencing the Red List published by the International Union of Conservation of Nature (IUCN). The conservation categories outlined by the IUCN are used here in quotations and capitalized to distinguish them from the text. Where possible, local conservation assessments were also noted. Once this research was completed, the second objective, creating a cultivar checklist was able to begin.

The goal of the cultivar checklist was to gather cultivar names for each taxon within the family. The exception being the genus *Hamamelis*, as its diversity is well documented by the International Cultivar Registration Authority (ICRA) for *Hamamelis*, the Arboretum Kalmthout in Belgium. The Arboretum Kalmthout has produced a thorough checklist for *Hamamelis*, complete with images of all the accepted cultivars. No other genus within the family has a dedicated ICRA. Review of Kalmthout Arboretum's online resources showed 182 registered cultivars of *Hamamelis*. The Kalmthout Arboretum also lists the following gardens as housing substantial *Hamamelis* collections; Delft University Botanical Gardens, Green Spring Gardens, Sir Harold Gardens, The Granary, Holden Arboretum, and the Royal Horticultural Society Wisley Garden (Arboretum Kalmthout.). For these reasons this assessment of the Hamamelidaceae will purposely exclude *Hamamelis* from the research and focus on the remaining genera. The cultivar checklist created for this thesis is intended to be a resource for others to use as a foundation to submit for review by an ICRA. The cultivar checklist for this thesis lists all cultivar names located within the limits of resources of this thesis and does not evaluate the validity of these cultivar names. Assembling this primary cultivar list is intended to eliminate

many of the initial steps an ICRA will have to complete, and not intended to substitute the work of a true Registration Authority.

Cultivar names were located through the Plant Search function of the Botanic Gardens Conservation International (BGCI) website. The Plant Search Function of BGCI lists taxa found within living collections of botanic gardens, parks, and arboreta that choose to report their collections statistics to BGCI. Only cultivar names were obtained through this process. Details on trademark, patents, introduction, and synonymy were not included in this step. These details were obtained using Michael Dirr's *Manual of Woody Landscape Plants* (1998) as an initial resource. Journal publications, and both library and online nursery catalogs were then reference for additional cultivar names and details. Where possible, differences in data were reconciled to create this primary cultivar checklist for the family. The process of reconciliation included researching similar cultivar names to assess which was actually correct, and review of species names that differed for a given cultivar to ensure the most correct taxon was used. A cultivar checklist for each genus is included in the *Species Description* section of this thesis, the full checklist for the family is listed in Appendix A.

To assess what members of the Hamamelidaceae are present in global living collections, two sets of collections statistics were obtained from BGCI. The Plant Search feature, cited above, does not include details on the number of individual plants, source, or provenance of the material. An additional data set was obtained from BGCI to provide this additional data from reporting institutions, as well as an export of the basic Plant Search data for all BGCI member institutions. The first dataset, here referred to as the BGCI Collections Survey detailed information at the individual plant

level. For each taxon in this report institutions provided the number of accessions, number of individual plants, provenance, and where applicable, wild collection data. The second report, the BGCI Institution Report, differs from the Survey in that it only reports if a given taxa is housed by an institution. For example, the BGCI Institution Report would only report that *Hamamelis virginiana* is housed by the University of Delaware Botanic Gardens, but it would not state how many accessions are in the UDBG collection, the provenance of the material, or how many plants are in the UDBG collection.

The BGCI Collections Survey provided collections details for 85 institutions representing 19 countries and covering the range of the family excluding Central and South America. BGCI stated that the BGCI Collections Survey was sent to 475 contacts. It is unclear if institutions did not respond due to the lack of Hamamelidaceae within their collections or just failed to respond. If the 475 contacts are presumed to be the same as the number of possible institution responses, then the response rate for the BGCI Collections Survey was just at 18%.

This dataset was then used to determine the numbers of individual plants for each taxon present in collections, and the number of institutions housing each taxon. Additionally, the conservation status reported in the species descriptions allowed for a comparison of conservation status to collection statistics. This allowed for recommendations to be made for additional taxa to be targeted on institutional desiderata. Where possible provenance information was compared to determine if wild collected materials are replicated between institutions, and that multiple populations are represented and documented for wild collected taxa.

The second dataset provided by BGCI, here referred to as the BGCI Institution Report, was simply a list of taxa and what institutions housed each taxon. A total of 354 institutions were included in this report of the 596 possible BGCI member gardens. As this data set was a download directly from BGCI in accordance with BGCI member garden requirements, it is no surprise that the response rate was 59%. This information was used to highlight general trends in the presence or absence of taxa in global collections and is discussed in greater detail in Chapter 3 of this thesis. In addition, both BGCI data sets are summarized at the end of each species description in Chapter 2. For the sake of clarity, terms specific to this analysis of the BGCI review are defined below:

**Accession:** all plants of the same taxon with identical source information

**BGCI Collections Survey:** a dataset created by BGCI that includes only BGCI member institutions. This report was created from uploaded *ex situ* records. This report only included the institution, country, and taxon. Uploads are recommended to be completed annually by BGCI member institutions.

**BGCI Institution Report:** living collections data submitted to BGCI from any institution that contributed their data. This living collections data included: institution, country, accession number, taxon, qualifier (where applicable), number of plants, provenance, lineage number, collection details, and living status.

**Institution:** the single organization that reported housing a particular taxon; public garden, private garden, botanic garden, arboretum, research center etc.

**Mass:** defined as three individual plants

**Plant(s):** individual living specimens within an accession



**Taxa/Taxon:** “a member of any taxonomic rank” (Pell, & Ingell, 2016). Here used mostly at the species level. As with the standard definition, context is critical in understanding how this term is intended when in text.

**Wild Provenance:** accessions that are documented as being collected directly from naturally occurring or non-cultivated populations of a given taxon (the term “wild collected” is a synonym)

It was useful to use abbreviations throughout this thesis. These abbreviations include; the Botanic Gardens Conservation International (BGCI), the International Plant Names Index (IPNI), Missouri Botanical Garden (MOBOT), Royal Botanical Gardens (RBG), International Cultivar Registration Authority (ICRA), Queensland Herbarium, Brisbane, Australia (BRI), University of Michigan Herbarium (MICH), Kew Herbarium, Royal Botanical Gardens (K), and International Union of Conservation of Nature (IUCN).

## **1.2 Family Description**

The Hamamelidaceae is a family of woody plants that is distributed across temperate, subtropical and tropical regions. It is found in North America, Central America, South America, Africa, Australia, and Asia. Endress (1993) states that “most species within the family are narrow endemics or very restricted in their distribution mostly due to past climatic changes”. The members of the Hamamelidaceae can be trees or shrubs that have deciduous, semi-evergreen, or evergreen foliage with an alternate arrangement. The flowering structures vary greatly across the family. The flowers can be held singly, in rounded clusters, or racemes, and apetalous has evolved three times within the family (Endress, 1993). This family has cultural and economic

value as the source of a medical astringent, witch hazel (*Hamamelis virginiana*), the raw materials for wickerwork and construction rope (*Parrotiopsis jacquemontiana*), and many of the genera possess ornamental value for the landscape. Previously, lumber value was listed among the uses for this family, but with the taxonomic shift of *Liquidambar*, *Pteroliquidambar*, and *Altingia* to a new family, Altingiaceae, none of the remaining Hamamelidaceae have notable lumber characteristics (The Plant List 1.1., n.d.).

Sources cited as few as 21 and as many as 30 genera within the family. This thesis recognizes 27 genera (listed below), which includes the intergeneric hybrid  $\times$ *Sycoparrotia*. A review of the literature found species estimates between 80 and 140 species in the family. This thesis recognizes 117 accepted species. Some unresolved species are discussed where they have the potential to become accepted names. The genus count within the family is also variable.

<i>Chunia</i>	<i>Hamamelis</i>
<i>Corylopsis</i>	<i>Loropetalum</i>
<i>Dicoryphe</i>	<i>Maingaya</i>
<i>Disanthus</i>	<i>Matudaea</i>
<i>Distyliopsis</i>	<i>Molinadendron</i>
<i>Distylium</i>	<i>Mytilaria</i>
<i>Embolanthera</i>	<i>Neostrearia</i>
<i>Eustigma</i>	<i>Noahdendron</i>
<i>Exbucklandia</i>	<i>Ostrearia</i>
<i>Fortunearia</i>	<i>Parrotia</i>
<i>Fothergilla</i>	<i>Parrotiopsis</i>

*Rhodoleia*

×*Sycoparrotia*

*Sinowilsonia*

*Trichocladus*

*Sycopsis*

The intra-family relationships are presented here by combining research from Magallón (2007) on the Hamamelidoideae, Endress (1989) on the Hamamelidaceae, and Li, Bogle, and Klein (1999) on internal transcribed spacer sequencing of the Hamamelidaceae. The family has been broken up into five subfamilies (Li, Bogle, & Klein, 1999). These are the Exbucklandioideae, Hamamelidoideae, Disanthoideae, Mytilarioideae (Harms) and Rhodoleioideae (Endress, 1989; Li, Bogle, & Klein, 1999). The Hamamelidoideae is the largest subfamily and is the only subfamily further divided into tribes and subtribes. Within the subfamily Hamamelidoideae there has been much debate as to the relationship of the genera within the tribes and subtribes. Li, Bogle, & Klein (1999) found that the traditional subtribes Fothergilleae and Distylieae were closely related and proposed a new clade for combining them. This new clade includes; *Sycopsis*, *Distylium*, *Distiolopsis*, *Parrotia*, *Parrotiopsis*, and *Fothergilla*. No name was given to this subtribe in their publication so a working name of “Fothergillinae” is used in this thesis. Figure 1 shows the relationships within the family.

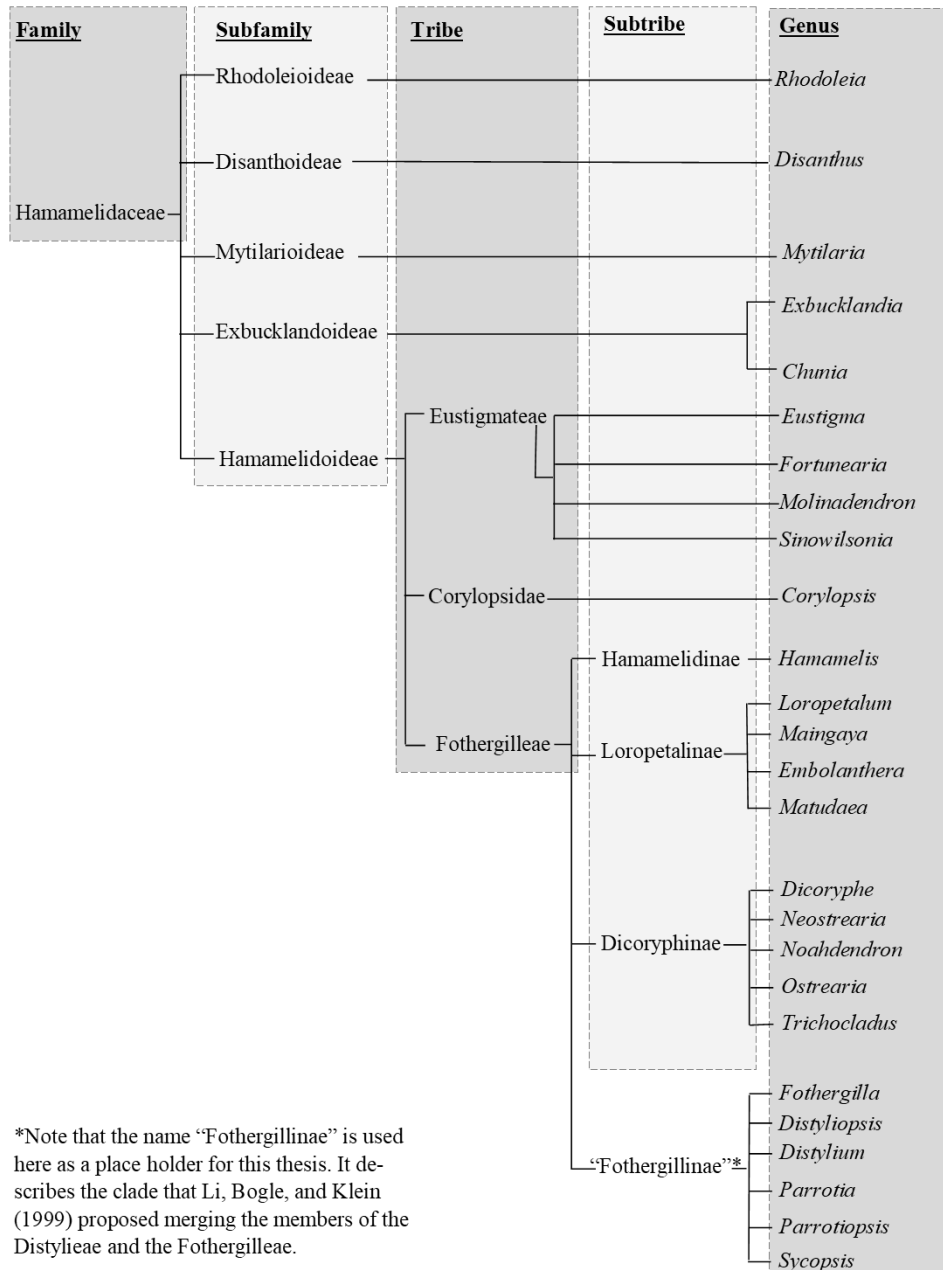
The Hamamelidoideae are characterized by a rigid endocarp, are bicarpellate, and each carpel has one functional ovule (Li, Bogle, & Klein, 1999). Within this subfamily, the members of the tribe Eustigmateae have auriculate petals, and an enlarged stigma (Li, Bogle, & Klein, 1999). The Fothergilleae has great morphological differences, but is unified by ITS sequencing, and the lack of a fixed merosity within the tribe (Li Bogle, & Klein, 1999). Within the Fothergilleae the Hamamelidinae is

distinguished by being four-merous. The Dicoryphinae is characterized the theca containing to pollen sacs that are covered by a single valve, and all members distributed in the southern hemisphere (Li, Bogle, & Klein, 1999). Most members of the Loropetalinae have strap-like petals that exhibit circinate coiling when in bud, have nectar producing lobes which are disc-shaped, and most members are pentamerous, excluding *Loropetalum* (Magallón, 2007).

Outside of the Hamamelidoideae the remaining subfamilies are mostly monogeneric. These include the Disanthoideae, Rhodoleioideae, and the Mytilarioideae (Li, Bogle, and Klein, 1999). Li, Bogle, and Klein (1999) note that the Rhodoleioideae is distinguished by its asymmetrical flower and having a chromosome base of  $x = 12$ . The remaining subfamily, the Exbucklandioideae is characterized by palmate leaf venation, large non-abscising stipules, and each carpel contains four to six ovules (Li, Bogle, & Klein, 1999).

In summary, the taxonomy for the family is presently in flux at all levels but numerous sources were cited that are attempting to reconcile this. The species descriptions in Chapter 2 include taxonomic and nomenclatural history as well as comparisons to closely allied taxa that attempt to better explain the present state of the Hamamelidaceae within taxonomic literature.

Figure 1 Taxonomic Relationships within the Hamamelidaceae



## Chapter 2

### SPECIES DESCRIPTIONS

#### 2.1 *Chunia* Overview

**Nomenclature and Taxonomy:** *Chunia* is in the subfamily Exbucklandioideae with *Exbucklandia* (Magallón, 2007). The leaf shape of these three genera is very similar, but several features make each genus distinct; *Chunia* is characterized by paired stipules, which it has in common with *Exbucklandia*, both *Chunia* and *Mytilaria* have multilacunar nodal anatomy with spicate flowers, whereas *Exbucklandia* is trilacunar, and *Chunia* has fewer flowers per inflorescence than *Mytilaria* (Bogle, 1991). *Chunia* is a monospecific genus with *Chunia bucklandioides* being the only accepted species (Huang et al., 2017). *Bucklandia populnea* R. Br. ex Griff is a synonym of this name (The Plant List 1.1., n.d.). Presently, *Bucklandia* as it relates to members of the Hamamelidaceae is invalid but remains a valid genus for a group of fossil cycadioids as described in the *Exbucklandia* genus description below (Jacobson, 2009). One of the isotypes examined of this species collected in 1934 lists *Bucklandia populnea* R. Br. as the original name on the voucher (Wang 00842372-01, 1934). No cultivars were located for this genus.

##### 2.1.1 *Chunia bucklandioides* H.T. Chang

Original Publication: H.T. Chang, *Sunyatsenia*. 7:63. 1948

*Chunia* is an evergreen tree that grows to 20 m (Meng et al., 2016; Flora of China, n.d.). Notes from an isotype collected state that the specimen is from a tree that was 20 m in height (Wang 00842372-01, 1934). Stems are stout with distinct nodes and prominent lenticels (Flora of China, n.d.). The bark is scabrous and described as

gray on the notes from the isotype (Flora of China, n.d.; Wang 00842372-01, 1934).

Buds are compressed globose and glabrous (Flora of China, n.d.).

Leaves are leathery, broadly ovate to rounded, tricuspidate or simple, 10-15 cm long, and 8-14 cm wide (Wu et al., 2009; Flora of China, n.d.). The margin is entire, the base is subcordate to truncate, and the apex is acuminate with a clear drip tip (Wu et al., 2009; Flora of China, n.d.; Huang et al., 2017). Venation is actinodromous, with five distinct palmate veins which are prominent adaxially, and convex abaxially (Flora of China, n.d.). The isotype clearly shows these venation characteristics (Wang 00842372-01, 1934). Adaxially, leaves are described by the Flora of China as “drying dark green, shiny”, and notes on the isotype state they are “green above” (Wang 00842372-01, 1934). The Flora of China describes the abaxial leaf as “yellow-green, glabrous”, and notes from the isotype state they are “pale green” (Wang 00842372-01, 1934). The petiole is thick and very long, being described as 7-13 cm in length (Wang 00842372-01, 1934; Flora of China, n.d.). When investigating nodal anatomy, Bogle discovered that the petiole base cut in cross section reveals two concentric xylem rings (1991). Other members of the Hamamelidaceae were examined this way, and none shared this characteristic (Bogle, 1991). Bogle hypothesized that *Chunia* may be the only member of the Hamamelidaceae to have this trait (1991).

Stomatal morphology is one distinguishing feature for members of the Exbucklandioideae. *Chunia* has a paracytic, or parallel, stomatal type (Wu, Sun, Liu, Xie, & Lin, 2009). However, this is a shared trait with *Disanthus*, which is in its own subfamily (Wu et al., 2009; Magallón, 2007). The other members of the Exbucklandioideae, *Mytilaria* and *Exbucklandia*, respectively have stephanocytic (weak rosette arrangement) and cyclocytic stomata (cells encircling guard cells) (Wu

et al., 2009). The stipules on *Chunia* are paired, 2-2.5 cm long, and are thick and leathery (Bogle, 1991; Flora of China, n.d.). They enclose buds, are quickly deciduous, and leave a distinct annular scar at the nodes (Flora of China, n.d.). Stipules on *Chunia* can be symmetric or asymmetric and are smaller than the stipules on *Exbucklandia* (Huang et al., 2017).

The bisexual flowers of *Chunia* are apetalous, spicate inflorescence that are “dark red” in color (Flora of China, n.d.; Wang 00842372-01, 1934). Each inflorescence has 12-16 flowers, each flower is 1.5 cm long and 0.5 cm wide, and each flower lacks sepals (Flora of China, n.d.). The inflorescence is placed terminally or sub-terminally. Flowering period is March to June, and the flowers open before the leaves (Flora of China, n.d.). Ovaries are sunken, which is unique to *Chunia* and *Mytilaria* in the family (Bogle, 1991). Fruiting period is June to September, and capsules are two-valved, dehiscent, and ovoid to globose (Flora of China, n.d.). Capsules are 15 mm in length, the entire infructescence is 3-4 cm in length. The seed is black to brown, very shiny, and ellipsoid in shape (Flora of China, n.d.). Despite the above floral descriptions, a 2017 publication states that the “flowers of *Chunia* are only know(n) from the original description of the genus by Chang (1948)” (Averyanov, Endress, Quang, Nguyen, & Van, 2017).

*C. bucklandioides* is endemic to southern Hainan in China, and only found on Mt. Diaolup and Mt. Jianfeng in wet valleys and rain forests at elevations of 300-600 m (Bogle, 1991; Manchester, Chen, Lu, & Uemura, 2009; Meng et al., 2016; Flora of China, n.d.). The notes from the isotype examined state that it was collected in “mixed woods” in Hainan (Wang 00842372-01, 1934). The IUCN Red List has *C. bucklandioides* listed as “Vulnerable”, due to the very limited range (IUCN Red List,



2018). The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

Table 1 *Chunia bucklandioides*: BGCI Institution Report and BGCI Collections Survey

<i>Chunia bucklandioides</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

## 2.2 *Corylopsis* Overview

**Nomenclature and Taxonomy:** The genus name is in reference to the similarity of *Corylopsis* to *Corylus* in leaf. The prefix meaning “hazel” and the suffix “opsis” means “to resemble” (Bean & Anisko, 2014). The genus name was first published in 1835 by German plantsmen, Philipp Siebold and Joseph Gerhard Zuccarini (Morley, & Chao, 1977). Commonly, the genus is referred to as the winterhazels, or winter hazels, but many of the species do not have a common name (Bean & Anisko, 2014). In 1997 Li, Bogle, & Klein observed that *Corylopsis* was not closely related to the other genera prescribed to the “*Corylopsis* Complex” as previously thought. The genera in this complex were *Distylium*, *Eustigma*, *Fortunearia*, and *Sinowilsonia* (Li, Bogle, & Klein, 1997).

There is great discrepancy in the literature as to the true number of species within the genus. This is due, in part, to the extreme variation in leaf shape, size, and pubescence. Reliance on floral characteristics has not been supported in the four species native to Japan (Yamananka, Kobayashi, & Setoguchi, 2008). These

designations were deemed inconsistent using both nrITS and cpDNA studies (Yamanaka, Kobayashi, & Setoguchi, 2008). In addition, the genus flowers long before leaves emerge, making duplicate collections for vouchered material necessary, a task often not achievable (Morely, & Chao, 1977). In 1977, Morley, & Chao state that “this situation, as well as the variability of the genus in China, has reduced parts of the taxonomy of the plants to a state of confusion.” In 2015, Gapinski was still lamenting that taxonomic confusion. Thus, the number of species ranges from seven to 33. For this thesis, 26 species are recognized, in accordance with the Plant List 1.1 and the Flora of China.

All species within the genus are native to east Asia. There are 20 species native to China, 19 of which are endemic (Flora of China, n.d.). Five species are found in Japan, three in India, and 1 species in Korea (Choung, Lim, Hwang, Kim, Lee, Ryu, & Lee, 2007). *Corylopsis* grows in warm temperate zones, on the edges of forests in rocky or mountainous terrains (Yamanaka, Kobayashi, & Setoguchi, 2008). In cultivation, *Corylopsis* flowers best in full sun to light shade (Bean, & Anisko, 2014). Although the genus has been in cultivation for almost two centuries, the species available in the trade are mostly limited to; *C. sinensis*, *C. glabrescens*, *C. spicata*, and *C. pauciflora* (Hatmaker, Wadl, Mantooth, Scheffler, Ownely, & Trigiano, 2015; Bean, & Anisko, 2014). There are about a dozen unique cultivars available in the trade. A cultivar list for this genus is listed at the end of the species descriptions.

**Description:** *Corylopsis* is a shrub or small tree. Branches are stellately pubescent in most species (Morley, & Chao, 1977). The leaf arrangement is alternate, and leaves can be deciduous, semi-evergreen, or evergreen (Li, Bogle, & Klein, 1997). Morley and Chao state that there is not consistent and significant difference in the

leaves amongst the species, but most sources find it helpful to use leaves as one part of identification of specimens (1977). The leaves are ovate, obovate, or orbicular, and most species have leaves that are between 7 and 10 cm in length. The leaf margin is toothed, and sometimes sinuate. Venation is pinnate, with young leaves appearing to have closer veins, but these expand with age. The adaxial surface is glabrous, and sometimes pubescent when immature. The abaxial surface can be glabrous to pubescent, and the presence or absence of hairs corresponds to those traits on the petiole. This is helpful for identification. The stipules are large and membranous, and are quickly deciduous (Morley, & Chao, 1977).

The petals are showy and commonly spatulate in shape (Li, Bogle, & Klein, 1997; Flora of China, n.d.). Flowers are bisexual, usually with five petals that are yellow in color and fragrant (Li, Bogle, & Klein, 1997; Morley and Chao, 1977). The flowers are arranged into short, drooping racemes that are held on short shoots in the axils (*Corylopsis*, 1920; Wilson, 1928; Morley, & Chao, 1977). Both the flowers and the inflorescence are subtended by bracts, and the flowers also have two bracteoles per flower (Flora of China, n.d.). The inflorescence bracts are membranous and brown, and the flower bracts are less membranous and green or pale brown in color (Morley, & Chao, 1977). Each flower has five conspicuous sepals, and two slender styles that protrude longer than the flower (Morley, & Chao, 1977). The ovary can be superior or semi-inferior. Each ovary is bilocular with two ovules (Morley, & Chao, 1977). Stigmas are consistently small and capitate (Morley, & Chao, 1977). It is common for most species to exhibit partial dichogamy, having the pistils mature sooner than the stamens to help prevent self-pollination (Wong, & Kato). The stamens occur in groups of five, and alternate with the five nectaries (Morley, & Chao, 1977). The filaments

are long, and progress from green to yellow or white as they mature (Hufford, & Endress, 1989; Morley, & Chao, 1977). The anthers are short, and dehisce when petals are expanded (Morley, & Chao, 1977). Anther thecae are one-sporangiate, each one dehiscing by two valves (Flora of China, n.d.).

*Corylopsis* flowers in early spring, but sets flower buds the preceding autumn (Wilson, 1928). Bracts cover each individual flower as well as the whole inflorescence (Morley, and Chao, 1977). The inflorescence bract protects the whole structure through winter, and is shed in February or March (Morley, and Chao, 1977). Then the bracts on the individual flowers are exposed and open to flower (Morley, and Chao, 1977). The flowering period is from March to April, and occurs before plants leaf out (Bean, & Anisko, 2014). Frosts can damage the flowers if the temperatures are well below freezing (Bean, & Anisko, 2014). *Corylopsis* is insect pollinated both in cultivation and the wild, but predominantly pollinated by members of the *Hymenoptera* and *Diptera* in the wild (Morley, & Chao, 1977). The fruit is a sub-globose or ovoid woody capsule that is loculicidally dehiscent by four valves (Morley, & Chao, 1977; Flora of China, n.d.).

### **2.2.1 *Corylopsis alnifolia* (H.Lév.) C.K.Schneid.**

Original Publication: Repert. Spec. Nov. Regni Veg. 12: 379 1913.

The *Flora of China* lists the common name as "桤叶蜡瓣花" or "qi ye la ban hua." *Berchemia alnifolia* H. Léveillé is a synonym to *Corylopsis alnifolia* and was described in 1912. *C. alnifolia* is a shrub growing to 2 m (Flora of China, n.d.). Stems are dark gray and glabrous becoming lenticellate with age (Flora of China, n.d.). The buds are glabrous and narrowly ovoid to globose (Flora of China, n.d.). Young leaves are suborbicular, 2-4 cm long and 2-3.6 cm wide (Scheider, 1913). The leaves are

leathery with a serrate margin on the apical part of the leaf (Flora of China, n.d.). The individual teeth are mucronate (Flora of China, n.d.). The leaf base is asymmetrical and cordate, the apex is rounded and mucronate (Schneider, 1913, Flora of China, n.d.). There are seven to eight lateral veins on each side of the midvein, and the two veins at the base have indistinct tertiary veins (Flora of China, n.d.). Adaxially the leaves are glabrous, and abaxially there is pubescence only along the veins (Flora of China, n.d.). Petioles are glabrous and 10-15 mm long (Flora of China, n.d.). The stipules are glabrous, oblong to ovate, and 5-7 mm long (Flora of China, n.d.).

Neither the *Flora of China* nor Schneider (1913) observed or described flowers of this species. Although some characteristics are inferred from the infructescence that was observed. The infructescence is a raceme that is 3-4 cm long which would have held 10-12 flowers (Schneider, 1913). Bracts are caducous and subtend both the inflorescence and individual flowers (Flora of China, n.d.). Sepals are glabrous, broadly ovate, and are the same length as the floral cup, which is 1 mm in length (Flora of China, n.d.). The ovary is glabrous and adnate to the floral cup (Flora of China, n.d.). The styles are 2-3 mm in length (Flora of China, n.d.). The peduncle is glabrous and 1.3-1.5 cm long (Flora of China, n.d.). Flowering period is from May to July (Flora of China, n.d.). The fruiting period is July to September, and each fruit is a glabrous capsule that is 6-7 mm long (Flora of China, n.d.)

*C. alnifolia* is only found in the Guizhou province of China in forests and on roadsides between 1,000 and 1,200 m elevation (Flora of China, n.d.). *C. alnifolia* is not listed as being of conservation concern. The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections.

[Table 2 *Corylopsis alnifolia*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis alnifolia</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	1
Countries	1	1
Accessions	N/A	2
Wild Provenance	N/A	0
Plants	N/A	2

### 2.2.2 *Corylopsis brevistyla* H.T.Chang

Original Publication: Sunyatsenia 7: 71 1948

The Flora of China lists the common name of *C. brevistyla* as “短柱蜡瓣花” or “duan zhu la ban hua.” There are no listed synonyms of this taxon. *C. brevistyla* is a shrub, but no source was located stating the size of this plant (Flora of China, n.d.).

The young stems are glabrous and have small white lenticels that are unique within the genus (Flora of China, n.d.). Buds are glabrous, narrowly ovoid, and 8-10 mm long (Flora of China, n.d.). Each bud scale is ovate (Flora of China, n.d.).

The leaves are obovate to rounded, 3-7 cm long, and 2.5-5 cm wide (Flora of China, n.d.). Like, *C. alnifolia*, the margins are serrate only above the middle of the leaf, and the individual teeth are mucronate (Flora of China, n.d.). The base of the leaf is cordate, but only mildly asymmetrical (Flora of China, n.d.). The apex is obtuse and either mucronate or acute (Flora of China, n.d.). There are six to eight lateral veins on side of the midvein, and no indication that basal veins have notable tertiary venation (Flora of China, n.d.). The adaxial surface is described as drying green, and abaxially the veins are villous but mature to be glabrescent (Flora of China, n.d.). Petioles are glabrous and 5-10 mm in length (Flora of China, n.d.). Stipules are 13-15 mm long

and 3-4 mm wide (Flora of China, n.d.). Due to the correlation of glabrous petioles to glabrous stipules (described in the introduction section of this genus), it is assumed that the stipules are indeed glabrous.

The inflorescence is 1.5 to 2 cm long and holds 14 to 18 flowers (Flora of China, n.d.). *C. brevistyla* is one of six species that hold upwards of 15 flowers per raceme. Both involucre and floral bracts are present and pubescent, the former being scale-like, rounded, and 1-1.2 cm long (Flora of China, n.d.). The floral bracts are ovate and just 3-4 mm in length (Flora of China, n.d.). Bracteoles are also present, oblong, and 1.2-1.5 mm (Flora of China, n.d.). The sepals are equal in length to the floral cup, and are almost rounded (Flora of China, n.d.). The petals are spatulate, claw-shaped at the base, 3-4 mm long, and 2-3 mm wide (Flora of China, n.d.). The ovary in *C. brevistyla* is not adnate to the floral cup, and this is a distinguishing identification feature (Morley, & Chao, 1977). The ovary is superior and glabrous (Morley, & Chao, 1977). The styles are persistent and 1-1.5 mm long (Morley, & Chao, 1977). The stamens are shorter than the sepals and are 2.5-3 mm long (Flora of China, n.d.). The peduncle is tomentose, 1 cm long, and has 1 or 2 basal leaves (Flora of China, n.d.). The flowering period is from April to June (Flora of China, n.d.). The fruit is a glabrous capsule that is 5-6 mm long (Flora of China, n.d.). The seeds are 3-4 mm long, and the fruiting period is from July to August (Flora of China, n.d.).

*C. brevistyla* is native to the northern parts of Yunnan Province in China (Flora of China, n.d.). It is found in forests at 1,200 m elevation (Flora of China, n.d.). This species is not listed as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.2.3 *Corylopsis calicola* C.Y. Wu**

Original Publication: Fl. Yunnanica 1: 126 1977.

Although this species is considered valid by *The Plant List 1.1*, the *Flora of China* and other sources do not provide descriptions for it. Specifically, the *Flora of China* states that it was not included because the authors had never observed specimens of *C. calicola*. A 2014 publication by Bean & Anisko state that they received seed from Shanghai Botanical Gardens, and that this taxon is not yet available in the trade in the United States. This species is not listed as being of conservation concern. *C. calicola* was not reported in either of the BGCI data sets. Perhaps if more institutions in China reported to the BGCI data sets, this species would have been reported. As such, no institutions reported this in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.2.4 *Corylopsis coreana* Uyeki**

Original Publication: Suigen Gakuho 41: 8 1924.

*C. coreana* is commonly known as the Korean winter hazel (Shim, Ha, Lee, Kim, & Kim, 2007). This species was once considered a variety of *C. gotoana*, *C. gotoana* var. *coreana* (Uyeki) T. Yamaz., but presently is accepted at the species level (The Plant List 1.1, n.d.). This species was recently trialed by Longwood Gardens in a horticultural evaluation of the genus and reported as performing the worst in the trial (Bean, & Anisko, 2014).

*C. coreana* is a shrub that grows from 1-2 m in height (Chung, & Cheon, 2000). The leaf of *C. coreana* is larger than that of *C. gotoana*, and *C. coreana* has a glabrous leaf whereas *C. gotoana* has a pubescent leaf (Choi, Ha, Jeong, Joo, Chang, & Coi, 2018). The flowers are yellow and 7 mm long (Chung, & Cheo, 2000). There



are more flowers per inflorescence on *C. coreana* than *C. gotoana*, which is another key identification feature between the two (Choi et al., 2018). The flowering period is early spring (Chung, & Cheon, 2000). The fruit is a capsule, each holding two seeds that are 4-5 mm in length (Chung, & Cheon, 2000).

*C. coreana* is endemic to central and south Korea (Chung, & Chen, 2000). It is the only species of *Corylopsis* native to Korea (Choung, Lim, Hwang, Kim, Lee, Ryu, & Lee, 2007). *C. coreana* is listed as “Endangered” by the IUCN Red List, and as a “Category II” Endangered Species by the Wildlife Protection Act (Choung et al., 2007). Choung et al. cite the limited number of populations and habitat as being a contributing factor to this status (2007). In addition, Choung et al. state that *C. coreana* is only found on north or northwest facing slopes in large, but isolated, populations (2007). There are only 37 recorded populations of this species, occurring between 100 and 1,200 m elevations (Choung et al., 2007). The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections.

[Table 3 *Corylopsis coreana*: BGCi Institution Report and BGCi Collections Survey

<i>Corylopsis coreana</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	14	7
Countries	7	6
Accessions	N/A	8
Wild Provenance	N/A	2
Plants	N/A	10

### 2.2.5 *Corylopsis glabrescens* Franch. & Sav

Original Publication: Enum. Pl. Jap. 2: 367 1878.

*C. glabrescens* is commonly known as the fragrant winterhazel (Dirr, 1998).

This species was first introduced to the United States through the Arnold Arboretum in 1905 (Gapinski, 2015). John George Jack, of the Arnold Arboretum, sent seeds of *C. glabrescens* to the Arboretum from his travels in Japan of that same year (Gapinski, 2015). Presently, this species is available in the trade with the Royal Horticultural Society listing ten suppliers, and brief internet search yielding a few sources in the United States.

*C. glabrescens* is a multi-stemmed shrub that grows 2.5 to 5 m (Bean, & Anisko, 2014). Young stems were observed to be lenticellate on an herbarium voucher from the Steere Herbarium (Gillis 00327521, 1978). Dirr states that the stems are rounded, slender, brown in color, and are “zig zag” (1998). The buds are sessile, prominent, and covered with only three scales (Dirr, 1998). Like most species, the leaves are deciduous (Royal Horticultural Society, n.d.). The leaves are ovate, 5-10 cm long, and 3-7 cm wide (Dirr, 1998). The margin is sinuate-dentate, and individual teeth are mucronate, turning down from margins (Dirr, 1998). Using a digitized herbarium voucher the base was observed to be cordate and asymmetrical on a voucher from 1968 (Murata, & Iwatsuki K000961826, 1968). The apex was observed on two vouchers to be acute and sometimes mildly mucronate (Harvard University Herbarium 00043395, 1923; Murata, & Iwatsuki K000961826, 1968). The veins are covered in silky hairs, numerous veins were observed on each leaf of a vouchered specimen (Morley, & Chao, 1977; Harvard University Herbarium 00043395, 1923). The adaxial surface is dark green, and abaxially the leaf is glabrous and glaucescent, with pubescence on the veins or with pubescence on the full surface of young leaves

(Morley, & Chao, 1977; Dirr, 1998). The petioles are also covered in silky hairs (Morley, & Chao, 1977).

Dirr states that the flowers are yellow and fragrant (1998). Bean, & Anisko note that *C. glabrescens* is indeed fragrant, and has the strongest scent of any species in the genus (2014). The inflorescence is a pendulous raceme that is 2.5 to 4 cm long, and held on a short shoot (Dirr, 1998). Both the peduncle and pedicels are glabrous (Weaver, 1976). Petals are spatulate and moderately lobed at the apex of each petal (Gillis 00327521, 1978). Bracts occur at the base of individual flowers and the inflorescence (Gillis 00327521, 1978). The flowering period is from March to April (Bean, & Anisko, 2014; Dirr, 1998). Capsules are glabrous, dehiscent, and two-valved (Weaver, 1976; Dirr, 1998). A voucher collected in June of 1968 was in fruit at the time of its collection (Murata, & Iwatsuki K000961826, 1968).

*C. glabrescens* is listed as native to Japan by both Bean and Anisko (2014) and Dirr (1998), endemic to Japan by Yamanaka, Koboyashi, and Setoguchi (2008), and the Royal Horticultural Society describes it as native to both Japan and Korea. As no other sources state that *C. glabrescens* is native to Korea, and *C. coreana* was stated to be the only species native to Korea by Chung and Cheon (2000) it is likely that the distribution listed by the Royal Horticultural Society is incorrect as Yamanaka, Koboyashi, and Setoguchi (2008) based their research on direct population observations.. *C. glabrescens* is found in sunny and moist areas, and often associated with serpentine rock (Bean, & Anisko, 2014). The collection notes from a 1968 herbarium specimen state that it was collected “at 600 m in light valley forest, Mt. Aterayama Japan” (Murata, & Iwatsuki K000961826, 1968). Bean and Anisko state that this is the hardiest species of *Corylopsis* and that it does well in northern gardens

(2014). This species is not listed by the IUCN Red List. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 4 *Corylopsis glabrescens*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis glabrescens</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	86	37
Countries	16	11
Accessions	N/A	115
Wild Provenance	N/A	16
Plants	N/A	160

### 2.2.6 *Corylopsis glandulifera* Hemsl.

Original Publication: Hooker's Icon. Pl. 29: t. 2818 1906

The Flora of China lists the common name as “腺蜡瓣花” or “xian la ban hua.” Synonyms for *C. glandulifera* include; *Corylopsis willmottiae* var. *chekiangensis* W.C.Cheng, *Corylopsis sinensis* var. *glandulifera* (Hemsl.) Rehder & E.H.Wilson, *Corylopsis hypoglauca* var. *glaucescens* W.C.Cheng, *Corylopsis hypoglauca* W.C.Cheng, and *Corylopsis glandulifera* var. *hypoglauca* (W.C.Cheng) H.T.Chang (The Plant List 1.1, n.d.). Like *C. calicola*, Bean and Anisko state that Longwood Gardens received seed of *C. glandulifera* from Shanghai Botanical gardens, and that it is not currently available in the trade (2014).

*C. glandulifera* is a shrub that grows to 3 m with young branches that are glabrous, and becoming lenticellate with age (Flora of China, n.d.). Buds are glabrous and narrowly ovoid (Flora of China, n.d.). The leaf is obovate to obovate-rounded, 5-8

cm long, and 3.5-5.5 cm wide (Flora of China, n.d.). The margin is serrate only on the apical half of the leaf (Flora of China, n.d.). The base is subcordate or rounded, often asymmetrical, and the apex is subacute (Flora of China, n.d.). There are six to eight lateral veins on each side of the midvein, the two basal veins having tertiary venation (Flora of China, n.d.). The Flora of China describes the adaxial surface as glabrous, and the abaxial surface as gray-white in color with stellate pubescence (n.d.).

However, Morley and Chao describe the venation as sericeous (although it is unclear as to what surface), and they describe the abaxial surface as glabrous (1977). No samples were able to be observed to confirm pubescence on these surfaces. The petiole is pubescent and 6-10 mm long (Flora of China, n.d.). The stipules are described as glabrous by the Flora of China, and this is counter to the correlation of these two structures sharing the same type of pubescence (n.d.). Stipules are narrowly oblong and 12-15 mm long (Flora of China, n.d.).

The inflorescence is held on terminal shoots, and no description of the number of flowers per inflorescence or length of the structure was located (Flora of China, n.d.). Within the flower, the sepals are glabrous and ovate with a sub-obtuse apex (Flora of China, n.d.). The petals are spatulate, 5-6 mm long, and 3-4 mm wide (Flora of China, n.d.). Bracts are present on both the inflorescence and the individual flowers (Flora of China, n.d.). The former being sub-rounded, adaxially villous, abaxially glabrous, and 0.8-1 cm in length. The floral bracts are ovate-rounded, sparsely pubescent, and 3-4 mm in length (Flora of China, n.d.). Bracteoles are also present. These are oblong, sparsely pubescent, and also 3-4 mm in length (Flora of China, n.d.). Both the floral cup and ovary are glabrous (Flora of China, n.d.). The styles are 5-6 mm long, and the stamens are 4-5 mm long (Flora of China, n.d.). The peduncle is

0.8-1.3 cm long, can be glabrous or pubescent, and has one or two basal leaves (Flora of China, n.d.). The flowering period is March to May (Flora of China, n.d.). The infructescence is 4-6 cm, and holds glabrous capsules that are 6-8 mm long (Flora of China, n.d.). The seeds are 3-4 mm long, and the fruiting period is from June to August (Flora of China, n.d.).

*C. glandulifera* is native to the Anhui, Jiangxi, and Zhejiang Provinces in China (Flora of China, n.d.). It is found on slopes and roadsides at elevations of 1,300 m (Flora of China, n.d.). This species is not listed as being of conservation concern. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 5 *Corylopsis glandulifera*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis glandulifera</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	20	9
Countries	8	4
Accessions	N/A	13
Wild Provenance	N/A	4
Plants	N/A	36

### 2.2.7 *Corylopsis glaucescens* Hand.-Mazz

Original Publication: Anz. Akad. Wiss. Wien, Math.-Naturwiss. Kl. 62: 130 1925.

The Flora of China lists the common name as “怒江蜡瓣花” or “nu jiang la ban hua.” *Corylopsis polyneura* H.L. Li is a synonym to *C. glaucescens* (The Plant

List 1.1, n.d.). *C. glaucescens* can be a shrub or small tree, and no information was located about the height of the species (Flora of China, n.d.). Young branches are glabrous and become minutely lenticellate with age (Flora of China, n.d.). The buds are glabrous, narrowly ovoid, and 1-1.5 cm long (Flora of China, n.d.).

The leaf is ovate-round or obovate-rounded, 5-12 cm long, and 4-8 cm wide (Flora of China, n.d.). The margin is serrate with individual teeth being mucronate (Flora of China, n.d.). The base is cordate and asymmetrical, and the apex is acute (Flora of China, n.d.). There are eight to nine lateral veins on each side of the midvein, and the two basal veins have tertiary venation (Flora of China, n.d.). The adaxial surface is villous only on the veins (Flora of China, n.d.). Although, Morley and Chao describe the veins as glabrous (1977). Abaxially, the surface is glabrescent and dries to a gray-white (Flora of China, n.d.). The petiole is glabrous and 10-20 mm long (Morley, & Chao, 1977; Flora of China, n.d.).

The inflorescence is 4-5 cm long and is held on terminal shoots (Flora of China, n.d.). The floral cup and ovaries are glabrous, and the styles are 2-3 mm long (Flora of China, n.d.). Sepals are shorter than the floral cup, and each sepal has a rounded apex (Flora of China, n.d.). The petals are oblanceolate, 3-4 mm long, and 1.5-1.7 mm wide (Flora of China, n.d.). The peduncle is 1-2 cm long and has one or two basal leaves (Flora of China, n.d.). The infructescence is 5-7 cm, which is longer than the inflorescence (Flora of China, n.d.). The glabrous capsules are 6-7 mm long and hold narrowly ovoid seeds that are 4-5 mm long (Flora of China, n.d.). The flowering period is from April to June, and the fruiting period is from June to August (Flora of China, n.d.).

*C. glaucescens* is native only to the northwest region of the Yunnan Province in China (Flora of China, n.d.). It is found in forests between 1,700 and 3,000 m in elevation (Flora of China, n.d.). This species is not listed as being of conservation concern. No institutions reported *C. glaucescens* in the BGCI data sets, but the New York Botanical Garden did list a “*C. glaucophylla*”. It is unclear if this name is meant to be *C. glaucophylla* since some online sources reference *C. glaucophylla* as a synonym to *C. glaucescens*, but none of these are reputable references. Two nurseries have offered *C. glaucophylla* for sale; Heronswood in Washington, and Buchholz & Buchholz Nursery in Oregon. In the Global Gardens Data Set, the Kuming Botanical Garden in China and the Charles R. Keith Arboretum in the United States reported *C. glaucescens*.

#### **2.2.8 *Corylopsis gotoana* Makino**

Original Publication: Bot. Mag. (Tokyo) 15: 111 1901.

*Corylopsis gotoana* has no common name outside of that of the genus. Numerous synonyms are listed for this species. These are; *Corylopsis coreana* var. *pubescens* Nakai, *Corylopsis glabrescens* var. *gotoana* (Makino) T.Yamanaka, *Corylopsis glabrescens* f. *gotoana* (Makino) T.Yamanaka, *Corylopsis glabrescens* f. *pubescens* (Nakai) T.Yamanaka, *Corylopsis gotoana* var. *pubescens* (Nakai) T.Yamaz., and *Corylopsis gotoana* f. *pubescens* (Nakai) H.Ohba (The Plant List 1.1, n.d.). Due to its hardiness, it was noted in 1920 that this is the only species worthy of cultivation in Massachusetts (*Corylopsis*, 1920). Since that time, additional species have been noted for their hardiness as well, including *C. glabrescens* and *C. spicata* (Bean, & Anisko, 2014). The flowers have five ovate petals that are yellow in color (Wong, & Kato, 2017).



*C. gotoana* is a deciduous tree that grows to 4.5 m (Wong, & Kato, 2017). No description of the leaf was able to be located. The inflorescence is a 3-6 cm long raceme that holds 5-10 flowers (Wong, & Kato, 2017). Each flower is five-merous, and has two pistils, which are longer than the petals (Wong, & Kato, 2017). There are five stamens per flower, and these are also longer than the petals (Wong, & Kato, 2017). The flowering period is from March to April (Wong, & Kato, 2017).

*C. gotoana* is endemic to Honshu and Shikoku in Japan (Yamanaka, Kobayashi, & Setoguchi, 2008). It is found on rocky terrain in temperate forests (Wong, & Kato, 2017). *C. gotoana* is not listed as being of conservation concern. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections. It should be noted that one of the accessions with wild provenance was reported as collected in South Korea which is outside of the documented distribution of *C. gotoana*.

[Table 6 *Corylopsis gotoana*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis gotoana</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	43	16
Countries	10	8
Accessions	N/A	34
Wild Provenance	N/A	9
Plants	N/A	48

### 2.2.9 *Corylopsis henryi* Hemsl.

Original Publication: Hooker's Icon. Pl. 29: t. 2819 1906

The Flora of China lists the common name for *C. henryi* as “鄂西蜡瓣花” or “e xi la ban hua.” *C. stelligara* Guillaumin is a synonym of *C. henryi* (The Plant List 1.1, n.d.). *C. henryi* is a shrub with gray-brown stems that are glabrous and lenticellate (Flora of China, n.d.). The terminal buds are glabrous, ellipsoid, and 0.8-1 cm long (Flora of China, n.d.). The leaves are obovate to rounded, 6-8 cm long, and 4-6 cm wide (Flora of China, n.d.). The leaf margin is sinuate-serrate with mucronate teeth (Flora of China, n.d.). The base is asymmetrical and cordate, and the apex is what? (Flora of China, n.d.). There are 8-10 lateral veins on each side of the midvein, and the two basal veins have tertiary veins that are at a 90 degree angle to the lateral veins (Flora of China, n.d.). The adaxial surface is glabrous, and the abaxial surface is pale gray-brown with sparse pubescence (Flora of China, n.d.). The petiole is puberulent and 8-10 mm long (Flora of China, n.d.). The stipules are glabrous, oblong, and 1.8-2 cm long (Flora of China, n.d.).

The inflorescence is 3-4.5 cm long on a 1.5 cm long peduncle (Flora of China, n.d.). Petals are narrowly spatulate, 6-7 mm long, and 3-3.5 mm wide (Flora of China, n.d.). The sepals are ovate with a rounded apex (Flora of China, n.d.). Floral bracts are also ovate, and are 7 mm long (Flora of China, n.d.). Bracteoles are abaxially glabrous, oblong, and 4-5 mm long (Flora of China, n.d.). The ovary is not adnate to the floral cup, which is a distinguishing feature (Flora of China, n.d.). The floral cup and the ovary are both glabrous, and the ovary is superior (Flora of China, n.d.). The styles are 5-6 mm, and the stamens are 5-7 mm long (Flora of China, n.d.). The flowering period is from April to June (Flora of China, n.d.). The infructescence is 5-6 cm long, capsules are 6-7 mm long, and the seeds are 4-5 mm (Flora of China, n.d.). The fruiting period is from to July to September (Flora of China, n.d.).

*C. henryi* is native to west Hubei and east Sichuan Provinces in China (Flora of China, n.d.). It grows in forests at approximately 1,000 m elevations (Flora of China, n.d.). *C. henryi* is not listed in the BGCI Collections Survey, but is listed in the BGCI Institution Report by the Atlanta Botanical Gardens in the United States.

Table 7 *Corylopsis henryi*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis henryi</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

#### 2.2.10 *Corylopsis himalayana* Griff.

Original Publication: J. Asiat. Soc. Bengal 23: 641 1854.

William Griffith described *C. himalayana* in 1854 from collections he made in the Himalayas (Turner, 2015). *Corylopsis grata* Griff. and *Corylopsis manipurensis* Hemsl. are synonyms of *Corylopsis himalayana* (The Plant List 1.1, n.d.). *C. himalayana* was difficult to source information on, and many herbarium vouchers and their notes were used to piece together a description. *C. himalayana* is a deciduous shrub with elliptic leaves with closely spaced venation and tomentose pubescence (Kingdon-Ward 02649923, 1948; Morley, & Chao, 1977). The petioles are sericeous and have tomentose pubescence (Morley, & Chao, 1977). From a type specimen at Kew (K000704917), the petioles were measured to be 1-2 cm long, and 6-8 vein pairs

were counted on the available leaves (Hooker, & Thomson K000704917, n.d.). Examining that same specimen and an additional type specimen confirmed that the margin has serrated teeth above the middle part of the leaf, as with other species, and that the base is cordate to subcordate (Hooker, & Thomson K000704918, n.d.). Reviewing all available digitized herbaria vouchers from the Kew Herbarium and the Steere Herbarium, the apex was repeatedly observed to be acuminate to mucronate.

A sketch of an individual flower included in a type specimen at Kew (K000704917) indicates that the petals are spatulate, with short stamens, and pubescent bracts. The dried inflorescence included in this same voucher were measured to be ca. 3 cm long. The flowering period is unclear as notes from an April 1948 voucher state that “flowering (is) over” (Kingdon-Ward 02649923, 1948). A voucher collected in February 1939 appears to be in flower and the leaves have not emerged (Kingdon-Ward 02649925, 1939). Finally, the notes from a collection in October 1948 state “just coming into flower. Fruits opening simultaneously” (Kingdon-Ward 02649924, 1948). This apparent discrepancy in flowering time could be due to inaccurate observation by myself of the state of the second voucher from February 1939, or it could be the difference in collection locations of the source material. The 1939 specimens were collected in Burma (Myanmar), and the 1948 collections were made in India. The seeds were observed to be ovate, black, and ca. 3-4 mm long (Hooker, & Thomson K000704918, n.d.). The fruit was observed on a dried specimen to be two-valved, and the infructescence on this sample measured ca. 5 cm long (Hooker, & Thomson K000704917, n.d.).

A type specimen of *C. himalayana* was collected in 1850 in India, but many specimens were collected in Myanmar as well (Hooker, & Thomson K000704917,

n.d.). Notes from an herbarium voucher state that *C. himalayana* is found in “thickets, subtropical pine forest belt, alt 5000\* (ft)” (Kingdon-Ward 02649925, 1939). Notes from collections in 1948 also state that it grows in thickets at elevations up to 2,100 m (Kingdon-Ward 02649924 & 02649923, 1948). This species is not listed as being of conservation concern. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 8 *Corylopsis himalayana*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis himalayana</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	7	5
Countries	5	0?
Accessions	N/A	9
Wild Provenance	N/A	0
Plants	N/A	0?

#### 2.2.10.1 *Corylopsis himalayana* var. *griffithii* (Hemsl.) B.D. Morley & J.M. Chao

*C. griffithii* Hemsl. is a synonym to *C. himalayana* var. *griffithii* (The Plant List 1.1, n.d.). The leaves are longer than 10 cm and are the largest leaf in the genus (Morley, & Chao, 1977). Morley and Chao note that this variety has only one petal per flower, but do not state if other features of this flower differ (1977). No information was found on the distribution or habitat of this taxon. This variety is not listed as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### 2.2.11 *Corylopsis microcarpa* H.T.Chang

Original Publication: Acta Sci. Nat. Univ. Sunyatseni 1960(1): 38 1960.

The Flora of China lists the common name of *C. microcarpa* as “小果蜡瓣花” or “xiao guo la ban hua.” *C. microcarpa* is a shrub that grows to 4 m (Flora of China, n.d.). Young stems are glabrous and slender, and when mature, dry to a dark brown with minute lenticels (Flora of China, n.d.). The buds are glabrous and ovoid-globose (Flora of China, n.d.). The leaves are obovate to obovate-rounded, 3-7 cm long, and 2-4 cm wide (Flora of China, n.d.). The margin is serrated just on the apical half of the leaf, and individual teeth are mucronate (Flora of China, n.d.). The base is sub-cordate or rounded and slightly asymmetrical, and the apex is acute (Flora of China, n.d.). There are 8-10 lateral veins on each side of the midvein, the two basal veins having small tertiary veins (Flora of China, n.d.). The adaxial surface is glabrescent and dries to a dark green (Flora of China, n.d.). Abaxially the leaves are villous along the veins, and stellately pubescent all over (Flora of China, n.d.). The petioles are glabrescent and 5-8 mm long (Flora of China, n.d.). The stipules are densely pubescent, ovoid, and 1.5-1.7 cm long (Flora of China, n.d.).

The inflorescence is a 4-4.5 cm long raceme (Flora of China, n.d.). The flowers are subsessile with obovate petals that are 2-3 mm long, and sepals are just 0.8-1 mm long (Flora of China, n.d.). Floral bracts are adaxially tomentose, ovate, and 1.8-2 mm long (Flora of China, n.d.). The floral cup is glabrous and 1.8-2 mm long, and the ovary is also glabrous (Flora of China, n.d.). Styles are less than 1 mm, stamens are 1.5-2 mm long, and staminodes are present and two-lobed (Flora of China, n.d.). The flowering period is March to May (Flora of China, n.d.). The fruit is a small, glabrous capsule that is 4-5 mm long (Flora of China, n.d.). The seeds are 2-3 mm long, and the fruiting period is June to August (Flora of China, n.d.).

*C. microcarpa* is native to southern Gansu Province and northern Sichuan Province in China (Flora of China, n.d.). It is found in mountainous areas at elevations between 800 and 1,400 m (Flora of China, n.d.). This species is not listed as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey

### **2.2.12 *Corylopsis multiflora* Hance**

Original Publication: Ann. Sci. Nat., Bot. IV, 15: 224 1861.

The Flora of China lists the common name of *C. multiflora* as “瑞木” or “rui mu.” The Plant List 1.1 sites many synonyms of *C. multiflora*. These are; *Corylopsis cavaleriei* H.Lév., *Corylopsis cordata* Merr. ex H.L.Li, *Corylopsis multiflora* var. *cordata* (Merr. ex H.L.Li) H.T.Chang, *Corylopsis multiflora* var. *multiflora*, *Corylopsis multiflora* var. *parvifolia* H.T.Chang, *Corylopsis stenopetala* Hayata, and *Corylopsis wilsonii* Hemsl. *C. multiflora* is a shrub or small tree with young branches that are glabrous or tomentose (Flora of China, n.d.). The branches mature to be glabrescent, gray-brown with some lenticels (Flora of China, n.d.). The buds are tomentose and gray-white in color (Flora of China, n.d.).

The leaves are sometimes semi-evergreen in this species (Flora of China, n.d.). The leaf shape is ovate, obovate, obovate-elliptic, or even sub-circular (Flora of China, n.d.). The leaves are 5-15 cm long and 4-8 cm wide (Flora of China, n.d.). The margin is serrate with individual teeth that are mucronate (Flora of China, n.d.). The base is cordate and moderately asymmetrical, and the apex is acute, acuminate, or attenuate (Morley, & Chao, 1977). There are 7-9 veins on each side of the midvein, the lowermost veins have indistinct tertiary veins, and all veins have tomentose pubescence (Flora of China, n.d.; Morley, & Chao, 1977). Abaxially, the surface is

glabrous or with pubescence just on the veins (Flora of China, n.d.). The petioles have tomentose pubescence and are 10-15 mm long (Flora of China, n.d.). Stipules are oblong, 18-20 mm, and it is unclear if they have the same pubescence as the petiole (Flora of China, n.d.).

The inflorescence is a 2-4 cm long raceme (Flora of China, n.d.). The flowers have five petals that are each oblanceolate, 3-5 mm long, and 1-2 mm wide (Flora of China, n.d.). Sepals are ovate and 1-1.5 mm long, and the bracts can be either glabrous or pubescent (Flora of China, n.d.). Both the floral cup and the ovary are glabrous, and the ovary is semi-inferior (Flora of China, n.d.). The styles are shorter than the stamens, and the stamens are 4-7 mm long (Flora of China, n.d.). The peduncle is glabrous or pubescent, and the pedicels are 1-2 mm long (Flora of China, n.d.). The infructescence is 5-6 cm long (Flora of China, n.d.). No information was able to be located for flowering period, fruiting period, or details on the fruiting structure. No digitized herbarium records were able to be located for this species.

The Flora of China states that *C. multiflora* is native to Fujian, Guangdong, Guangxi, Guizhou, Hubei, Hunan, Taiwan, and Yunnan in China. It is found in forests, on slopes and on roadsides at elevations between 1,000 and 1,500 m (Flora of China, n.d.). This species is not of known conservation concern. The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections. The wild provenance material reported in the BGCi Collections Survey of wild origin from Hubei, China.

[Table 9 *Corylopsis multiflora*: BGCi Institution Report and BGCi Collections Survey

<i>Corylopsis multiflora</i>	BGCi Institution Report	BGCi Collections Survey
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Institutions	13	8
Countries	6	5
Accessions	N/A	11
Wild Provenance	N/A	1
Plants	N/A	19

#### 2.2.12.1 *Corylopsis multiflora* var. *multiflora* Hance

The common name of *C. multiflora* var. *multiflora* is “瑞木 (原变种)” or “rui mu (yuan bian zhong).” (Flora of China, n.d.). There are several synonyms listed of this taxon. These are; *Corylopsis cavaleriei* H. Léveillé, *C. cordata* Merrill ex Li, *C. multiflora* var. *cordata* (Merrill ex Li) H. T. Chang, *C. multiflora* var. *parvifolia* H. T. Chang, *C. stenopetala* Hayata, and *C. wilsonii* Hemsley (Flora of China, n.d.). The young stems are tomentose, and the leaves are stellately pubescent on the abaxial surface (Flora of China, n.d.). The stamens are 6-7 mm long, which is longer than *C. multiflora* var. *nivea* (Flora of China, n.d.). The peduncle is pubescent, and this is another difference between the two varieties (Flora of China, n.d.). The flowering period is April to June, and the fruiting period is June to September (Flora of China, n.d.). The capsules are glabrous, sessile, 12-20 mm long, and 8-14 mm wide with a thick pericarp (Flora of China, n.d.). The seeds are 8-10 mm long (Flora of China, n.d.). No information was located about the habitat or distribution. This variety is not of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.12.2 *Corylopsis multiflora* var. *nivea* H.T. Chang**

The Flora of China lists the common name as “白背瑞木” or “bai bei rui mu.” Unlike *C. multiflora* var. *multiflora*, this variety has young stems that are glabrous (Flora of China, n.d.). The leaves are ovate, 5-11 cm long, and 4-6.5 cm wide (Flora of China, n.d.). The abaxial surface can be glaucous or glabrous, and the petiole is consistently glabrous (Flora of China, n.d.). The petals are narrowly oblanceolate, 3 mm long, and 1-1.5 mm wide (Flora of China, n.d.). Bracts are present on both the flowers and the base of the inflorescence (Flora of China, n.d.). The inflorescence bracts are glabrous on the abaxial surface, and the floral bracts are pubescent (Flora of China, n.d.). The stamens are short, just 4 mm, and the peduncle is glabrous, both features unique for this variety (Flora of China, n.d.). The flowering period is strictly in May (Flora of China, n.d.). The fruiting structures were not observed or described for this variety. This variety is only found in the northern part of Fujian Province in China (Flora of China, n.d.). This variety is not of known conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.13 *Corylopsis obovata* H.T.Chang**

Original Publication: Sunyatsenia 7: 72 1948.

The Flora of China lists the common name of *C. obovata* as “黔蜡瓣花” or “qian la ban hua.” *C. obovata* is a shrub with young stems that are stellately pubescent and become glabrescent with age (Flora of China, n.d.). Buds have gray pubescence and are narrowly ovoid (Flora of China, n.d.). The leaves are obovate or obovate-rounded, 4-6 cm long, and 3.5-4 cm wide (Flora of China, n.d.). The margin is serrulate on the upper half of the leaf (Flora of China, n.d.). The base is obtuse or

subrounded, and the apex is rounded or truncate terminating in a mucronate tip (Flora of China, n.d.). There are 7-8 lateral veins on each side of the midvein, the basal two veins have indistinct tertiary veins (Flora of China, n.d.). Adaxially the surface is glabrous, and abaxially the surface has brown, stellate pubescence and is villous only along the veins (Flora of China, n.d.). The petiole is pubescent and 10-15 mm long (Flora of China, n.d.).

The flowers were not described in the Flora of China as the authors were not able to observe them (Flora of China, n.d.). No additional sources were able to be located with flower descriptions or of digitized herbarium vouchers. The infructescence is held on terminal shoots that 4-5 cm long (Flora of China, n.d.). The peduncle is villous and 1.8-2 cm long (Flora of China, n.d.). The peduncle has one to three basal leaves (Flora of China, n.d.). The infructescence holds 15-20 capsules in a dense arrangement and each capsule is glabrous and 6-7 mm (Flora of China, n.d.). The fruiting period is in August (Flora of China, n.d.).

*C. obovata* is native to the Chongqing municipality and Guizhou Province of China in forests at elevations between 1,000 and 1,200 m (Flora of China, n.d.). This species is not listed as being of conservation concern by the IUCN Red List. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.14 *Corylopsis omeiensis* W.C. Cheng**

Original Publication: Contr. Biol. Lab. Chin. Assoc. Advancem. Sci., Sect. Bot. 12: 133 1941.

The *Flora of China* lists the common name of *C. omeiensis* as “峨眉蜡瓣花” or “e mei la ban hua.” *C. omeiensis* is a shrub that grows to 3 m in height (Flora of

China, n.d.). The young stems are glabrous and slender, maturing to be dark brown when dried, and having small and sparse lenticels (Flora of China, n.d.). The buds are glabrous and narrowly ovoid (Flora of China, n.d.).

The leaf is glabrous, obovate-rounded or obovate-elliptic, 4-8 cm long, and 2.5-5.5 cm wide (Flora of China, n.d.). The margin can be either entire or serrate, the serration occurring on the apical half of the leaf (Flora of China, n.d.). The individual teeth are vaguely mucronate (Flora of China, n.d.). The leaf base is asymmetrically cordate, and the apex is obcordate or truncate (Flora of China, n.d.). There are 6 to 7 lateral veins on each side of the midvein, the two most basal veins have indistinct tertiary venation (Flora of China, n.d.). The abaxial surface is glabrous and gray-white in color (Flora of China, n.d.). The petioles are glabrous and 10-18 mm long (Flora of China, n.d.). The stipules are membranous, oblong-lanceolate, and 12-17 mm long (Flora of China, n.d.).

The inflorescence is held on terminal shoots and holds 12-16 flowers (Flora of China, n.d.). The sepals are shorter than the floral cup and have a rounded apex (Flora of China, n.d.). The petals are spatulate with a shortly clawed base and are 2-1.5 mm long (Flora of China, n.d.). Both the inflorescence and individual flowers have bracts. The former being elliptic, adaxially villous, 1-1.2 cm long, and 0.6-0.7 cm wide (Flora of China, n.d.). The flower bracts are ovate-rounded, glabrous, and 2-3 mm long (Flora of China, n.d.). Bracteoles are also glabrous and 1.2-1.5 mm long (Flora of China, n.d.). The floral cup is glabrous and less than 1 mm (Flora of China, n.d.). The ovary is also glabrous, and the styles are 1.2-1.5 mm long (Flora of China, n.d.). The peduncle is glabrous, 1-1.5 cm long, and has two basal leaves (Flora of China, n.d.). The flowering period is March to June (Flora of China, n.d.). Capsules are 5-6 mm

long, seeds are 2.5-3 mm long, and the fruiting period is from June to August (Flora of China, n.d.).

*C. omeiensis* is native to montane forests in the Guizhou and Sichuan Provinces in China at elevations ca. 1,500 m (Flora of China, n.d.). This species is not listed as being of conservation concern by the IUCN Red List. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.2.15 *Corylopsis pauciflora* Siebold & Zucc.**

Original Publication: Fl. Jap. 1: 48 1838

The common name of *C. pauciflora* is listed as “buttercup winterhazel” (Del Tredici, 2017). *C. mautsudae* Kaneh. & Sasaki is a synonym of *C. pauciflora* (The Plant List 1.1., n.d.). Wilson (1928) describes *C. pauciflora* as “the oldest species in cultivation” within the genus, it was introduced in 1862 (Dirr, 1998). Weaver states that “most species in cultivation are likely of Japanese origin” (1976). *C. pauciflora* is a shrub, and in full sun can be quite dense (Bean, & Anisko, 2014). This was the lowest growing species in Longwood’s *Corylopsis* trials, growing to 1.8 m in height (Bean, & Anisko, 2014). Branches have a fine texture and are glabrous when young (Flora of China, n.d.; Bean, & Anisko, 2014). The buds are glabrous, and no description was located as to bud shape or size (Flora of China, n.d.).

The leaves of *C. pauciflora* are the smallest of any *Corylopsis* (Morley, & Chao, 1977). The leaves are ovate-elliptic or broadly ovate, 3-6.5 cm long, and 2-3.5 cm wide (Flora of China, n.d.). The margin is serrated on the apical half of the leaf, and individual teeth are mucronate (Flora of China, n.d.). The base is rounded or subcordate and asymmetrical, and the apex is acute (Flora of China, n.d.). There are six to eight lateral veins on each side of the midvein, the two basal veins have

indistinct tertiary venation (Flora of China, n.d.). The abaxial surface is glabrous and villous only along the lateral veins (Morley, & Chao, 1977; Flora of China, n.d.). The petioles are slender, pubescent, and 5-10 mm long (Flora of China, n.d.). Although the fall color is not consistently ornamental, the new growth in spring is often reddish and adds ornamental impact to the garden (Bean, & Anisko, 2014).

The yellow flowers are fragrant and are held in a drooping raceme (Dirr, 1998; Bean, & Anisko, 2014). Despite the inflorescence only having two to five flowers per inflorescence, the large size of the flowers and large number of inflorescences still makes this a very ornamental species (Bean, & Anisko, 2014). The inflorescence is 1-2 cm long, making it the shortest in the genus (Morley, & Chao, 1977; Flora of China, n.d.). The petals are obovate and 6-7 mm long (Flora of China, n.d.). The sepals are glabrous, triangular, and the apex is often obtuse (Flora of China, n.d.). The bracteoles are shorter than the bracts (Flora of China, n.d.). Both the floral cup and ovary are glabrous (Flora of China, n.d.) The styles and the stamens are both 5-6 mm long (Flora of China, n.d.). The peduncle is glabrous and short (Flora of China, n.d.). The flowering period is described as March to May in Kennett Square, Pennsylvania by Bean and Anisko (2014). The flowering period is described as May to July in the *Flora of China* (n.d.). This difference can be attributed to geography. The early flowers are often destroyed by frost (Corylopsis, 1920). Capsules are glabrous, 6-8 mm long, and the fruiting period is from July to September (Flora of China, n.d.).

All sources agree that *C. pauciflora* is native to Japan and Taiwan, but Weaver states that it is also native to Korea (1976). A 2007 publication states that *C. coreana* is the only species native to Korea, so it is likely that Weaver's assertion is no longer valid (Choung et al., 2007). *C. pauciflora* grows on moist slopes and forests at

elevations between 200 and 300 m (Flora of China, n.d.). This species is associated with serpentine rock outcrops (Bean, & Anisko, 2014). *C. pauciflora* is hardy in USDA Zones 6 to 8, and can tolerate more sun and heat than other species (Dirr, 1998; Bean, & Anisko, 2014). The IUCN Red List states that *C. pauciflora* is “Data Deficient”. Despite the lack of population data in collections it has high representation. The table below shows a summary of the two BGCI data sets for this taxon in ex situ collections.

[Table 10 *Corylopsis pauciflora*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis pauciflora</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	119	43
Countries	17	14
Accessions	N/A	94
Wild Provenance	N/A	4
Plants	N/A	177

### 2.2.16 *Corylopsis platypetala* Rehder & E.H.Wilson

Original Publication: Pl. Wilson. 1: 426 1913.

The Flora of China lists the common name of *C. platypetala* as “阔蜡瓣花” or “kuo la ban hua.” *C. platypetala* var. *levis* Rehder & E.H. Wilson is a synonym (The Plant List 1.1, n.d.). Ernest Henry Wilson introduced *C. platypetala* in 1907 (Dirr, 1998). *C. platypetala* is a shrub that grows to 2.5 m (Flora of China, n.d.). Young stems are often glandular pubescent, becoming glabrescent and lenticellate with age (Flora of China, n.d.). The bark is considered attractive, but not showy (Bean, &

Anisko, 2014). It is light brown-gray in color with lighter patches (Bean, & Anisko, 2014). The buds are glabrous, and the flower buds are slender and come to a narrow point (Flora of China, n.d.; Weaver, 1976).

The leaves are ovate or broadly ovate, 7-10 cm long, and 4-7 cm wide (Flora of China, n.d.). The leaf has a serrate margin and the individual teeth? are mucronate (Flora of China, n.d.). The leaf base is cordate and can be symmetrical or asymmetrical, and the apex is shortly acute (Flora of China, n.d.). There are 6-10 veins on each side of the midvein, and the two basal veins have tertiary venation (Flora of China, n.d.). The adaxial surface is villous (Flora of China, n.d.). Dirr states that specimens grown in full sun will develop a waxy bloom (1998). Abaxially, leaves are described as glabrous by Morley, & Chao (1977), and as villous by the Flora of China (n.d.). It is unclear if this is just variation within the species. The petioles are pubescent, occasionally glandular, and 12-15 mm long (Flora of China, n.d.). The stipules are oblong or oblong lanceolate and 20-30 mm long (Flora of China, n.d.). The apex of the stipule is acute, abaxially glabrous, and adaxially villous (Flora of China, n.d.).

The inflorescence is 2-2.5 cm long and holds 8-20 flowers (Flora of China, n.d.). Each flower can be up to 0.6 cm long, but often is shorter (Weaver, 1976). The flowers are yellow to greenish and fragrant (Dirr, 1998; Weaver, 1976). Each petal is 3-4 mm long, 4 mm wide, and the base is shortly clawed (Flora of China, n.d.). The sepals are glabrous, ovate, and have an obtuse apex (Flora of China, n.d.). Both the inflorescence and the individual flowers are subtended by bracts (Flora of China, n.d.). The inflorescence bracts are caducous, and the floral bracts are oblong, 4-5 mm long, and have sparse pubescence (Flora of China, n.d.). Bracteoles are also caducous (Flora



of China, n.d.). Both the floral cup and ovary are glabrous, and the ovary is semi-inferior (Flora of China, n.d.). The styles are shorter than the stamens, and the stamens are less than 4 mm long, always shorter than the petals (Flora of China, n.d.). The peduncle is subglabrous and 1.5-2 cm long (Flora of China, n.d.). The flowering period is April to July, and in cultivation *C. platypetala* flowers before *C. willmottiae* (Flora of China, n.d.; Morley, & Chao, 1977). The glabrous capsules are 7-9 mm long, seeds are 4-5 mm long, and the fruiting period is July to September (Flora of China, n.d.).

*C. platypetala* is native to Anhui, Hubei, and Sichuan provinces in China. It is common in thickets and wood edges, at elevations between 1,300 and 2,600 m (Dirr, 1998; Flora of China, n.d.). It is hardy to USDA Zones 6 to 8 (Dirr, 1998). This species is not listed by the IUCN Red List as being of conservation concern. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 11 *Corylopsis platypetala*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis platypetala</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	32	18
Countries	14	10
Accessions	N/A	25
Wild Provenance	N/A	0
Plants	N/A	39

### 2.2.17 *Corylopsis rotundifolia* H.T.Chang

Original Publication: Acta Sci. Nat. Univ. Sunyatseni 1960(1): 37 1960.

The Flora of China states that the common name of *C. rotundifolia* is “圆叶蜡瓣花” or “yuan ye la ban hua.” *C. rotundifolia* is a shrub that grows to 2-3 m in height (Flora of China, n.d.). Young stems are tomentose with yellow-brown hairs, the stems mature to glabrescent, sparsely lenticellate branches (Flora of China, n.d.). The buds are tomentose and narrowly ovoid (Flora of China, n.d.). The leaves are rounded or sub-rounded and 4-8 cm long (Flora of China, n.d.). The margin is serrate, with individual teeth being mucronate and 1 mm long (Flora of China, n.d.). The base is cordate and sub-symmetrical, and the apex is rounded, but comes to a mucronate point (Flora of China, n.d.). There are six to nine veins on each side of the midrib, and the basal two veins have indistinct tertiary venation (Flora of China, n.d.). The adaxial surface is pubescent only along the veins, and the abaxial surface is sparsely pubescent and is villous along the veins (Flora of China, n.d.). The petiole is tomentose and 7-12 mm long (Flora of China, n.d.). The stipule oblong, 8-13 mm long, 4-5 mm wide, and is pubescent, hairs are yellow-brown in color and present on both sides (Flora of China, n.d.).

The inflorescence is held on terminal shoots, and the number of flowers per inflorescence was not able to be located (Flora of China, n.d.). The sepals are ovate-rounded, 0.8-1 mm long, and have a rounded apex (Flora of China, n.d.). The petals are broadly ovate, 2-3 mm long, 2-2.5 mm wide, and are basally clawed (Flora of China, n.d.). Basal bracts are present on both the inflorescence and individual flowers (Flora of China, n.d.). There are four to six bracts at the base of the inflorescence, each bract is ovate-rounded, 1.2-1.5 cm long, 1-1.2 cm wide, and both surfaces are densely tomentose (Flora of China, n.d.). Floral bracts are ovate, pubescent, and 3-4 mm long (Flora of China, n.d.). The bracteoles are oblong, pubescent, and 2-3 mm long (Flora

of China, n.d.). The floral cup and ovary are glabrous, and both are 1.2-1.5 mm long (Flora of China, n.d.). The stigmas are slightly expanded, and the stamens are 1.5-2 mm long (Flora of China, n.d.). The peduncle is tomentose, 1.5 cm long, and is subtended by two to three basal leaves (Flora of China, n.d.). The flowering period is March to May (Flora of China, n.d.). The infructescence is 4.5 cm long holding 10-17 capsules which are 5-6 mm in diameter (Flora of China, n.d.). The seeds are 3-3.5 mm long, and the fruiting period is June to August (Flora of China, n.d.).

*C. rotundifolia* is native to the Chongqing municipality and Guizhou province in China (Flora of China, n.d.). It is found in montane forests at elevations of 1,200 m (Flora of China, n.d.). This species is not reported as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.18 *Corylopsis sinensis* Hemsl.**

Original Publication: Gard. Chron. III, 39: 18 1906.

The Flora of China lists the common name of *C. sinensis* as “蜡瓣花” or “la ban hua.” Synonyms to *C. sinensis* are *Corylopsis sinensis* var. *sinensis* Hemsl., and *C. sinensis* var. *parvifolia* H.T. Chang (The Plant List 1.1). Bean and Anisko state that *C. sinensis* is a species that has been split and merged repeatedly over its history (2014). *C. sinensis* was introduced by Ernest Henry Wilson while on a collecting trip for Veitch and Son, whom *C. veitchiana* is named after (Weaver, 1976). Bean and Anisko (2014) mention two varieties of *C. sinensis*; *C. sinensis* var. *calvescens* *C. sinensis* var. *sinensis*. *The Plant List 1.1* recognizes *C. sinensis* var. *sinensis* as a synonym to the species and does not recognize *C. sinensis* var. *calvescens* at all. The former variety is supposed to have a longer inflorescence than that of *C. sinensis* var.

*calvescens* (Flora of China, n.d.). However, as no other sources were located recognizing these varieties they are not recognized as being valid in this thesis. *C. sinensis* is a large shrub with pubescent or glabrous branches (Flora of China, n.d.). The bark is attractive, but not showy (Bean, & Anisko, 2014). It has light brown-gray bark with lighter patches, much like that of *C. platypetala* (Bean, & Anisko, 2014).

The leaves are obovate, obovate-rounded, broadly ovate, or oblong-obovate (Flora of China, n.d.). The leaves are 3-9 cm long and 2-6 cm wide (Flora of China, n.d.). The leaf margin is serrate and individual teeth are mucronate (Flora of China, n.d.). The base is asymmetrical, cordate or sub-truncate, and the apex is obtuse, acute, or acuminate (Flora of China, n.d.). There are seven to nine veins on each side of the midrib and two basal veins have indistinct tertiary venation (Flora of China, n.d.). The adaxial surface is glabrous, or pubescent just along the veins, and the abaxial surface is gray-brown, stellately pubescent or glabrous (Flora of China, n.d.). The petiole is stellately tomentose and 5-10 mm long (Flora of China, n.d.). The stipules are sparsely pubescent, narrowly oblong, and 20 mm long (Flora of China, n.d.).

The inflorescence is 3-4 cm long with 11 or more flowers (Weaver, 1976). The flowers are yellow-green with spatulate petals that are 5-6 mm long and 3-4 mm wide (Bean, & Anisko, 2014; Flora of China, n.d.). Sepals are glabrous, ovate, and have a subobtusate apex (Flora of China, n.d.). The floral bracts are pubescent, ovate, and 4-5 mm long (Flora of China, n.d.). The bracteoles are oblong and 2-3 mm long (Flora of China, n.d.). The floral cup and ovary are both stellately pubescent (Flora of China, n.d.). The styles are 6-7 mm long with pubescence at the base (Flora of China n.d.). Stamens are 4-5 mm long (Flora of China, n.d.). The peduncle is pubescent and 1.2-1.5 cm long (Flora of China, n.d.). The flowering period is from March to April (Bean,

& Anisko, 2014). The infructescence is 3-6 cm long (Flora of China, n.d.). The capsules are 10-14 mm long and 7-9 mm wide with stellate pubescence, and the seeds are 4-5 mm long (Flora of China, n.d.).

*C. sinensis* is endemic to China but has a range that covers several provinces (Flora of China, n.d.). These provinces are; Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hubei, Hunan, Jiangxi, Sichuan, and Zhejiang (Flora of China, n.d.). *C. sinensis* is found in montane forests between 1,000 and 1,500 m elevations (Flora of China, n.d.). In cultivation, *C. sinensis* is hardy to USDA Zone 6 (Bean, & Anisko, 2014). This species is not listed as being of conservation concern. Both *C. sinensis* var. *sinensis* and *C. sinensis* var. *calvescens* were reported in the BGCI Institution Report. These varieties were included in the total reports of *C. sinensis*; *C. sinensis* var. *sinensis* was reported by 40 institutions, and *C. sinensis* var. *calvescens* was reported by 50 institutions. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table12 *Corylopsis sinensis*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis sinensis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	114	45
Countries	19	13
Accessions	N/A	212
Wild Provenance	N/A	48
Plants	N/A	282

### **2.2.19 *Corylopsis spicata* Siebold & Zucc.**

Original Publication: Fl. Jap. 1: 45 1838.

*C. spicata* is commonly called the spike winterhazel (Del Tredici, 2017). *C. kesakii* Siebold & Zucc. is a synonym to *C. spicata* (The Plant List 1.1, n.d.). *C. spicata* was part of Thomas Hogg's first shipment of plants, as a published inventory in *The Horticulturist* in 1863 (Wilson, 1928). This species is one of the oldest in cultivation, believed to be introduced in 1862, the same year as *C. pauciflora* (Weaver, 1976; Wilson, 1928). *C. spicata* is an arching shrub that can reach 3.5 m in height (Bean, & Anisko, 2014). The branches have a distinct zigzag pattern (Bean, & Anisko, 2014). The vegetative buds are dark red in bud and mature to green (Royal Horticultural Society, n.d.). This makes the new growth appear purplish in color (Dirr, 1998). The leaves are broadly ovate or orbicular-ovate, 5-10 cm long, and 5-7.5 cm wide (Royal Horticultural Society, n.d.; Dirr, 1998). The margin is toothed with bristled tips (Royal Horticultural Society, n.d.). The base is obliquely-cordate to rounded, and the apex is abruptly short acuminate (Dirr, 1998). The adaxial surface is bright green and tomentose only on the veins (Morley, & Chao, 1977). Abaxially, the leaves are blue-green and sericeous (Morley, & Chao, 1977; Royal Horticultural Society, n.d.). The petioles are tomentose and 1.25-2.5 cm long (Morley, & Chao, 1977; Dirr, 1998).

The inflorescence is a 10-15 cm long raceme that holds fewer than 10 flowers per inflorescence (Royal Horticultural Society, n.d.; Weaver, 1976). The flowers are a true yellow and fragrant with spatulate petals (Bean, & Anisko, 2014; Morley, & Chao, 1977). The anthers are dark red to purple, and add ornamental interest to the flower (Bean, & Anisko, 2014). Although the flowering period was not able to be found, it was noted that flower buds are often killed by frosts (*Corylopsis*, 1920).

*C. spicata* is described as endemic to Japan by Bean and Anisko (2014) as well as Yamanaka, Kobayashi, and Setoguchi (2008). The Royal Horticultural Society lists as being native to China as well, but the Flora of China does not list *C. spicata* as being native. This appears to be enough to support *C. spicata* as being endemic to only Japan. *C. spicata* is found on serpentine soil and rock outcrops, specifically on Shikoku Island, Japan (Bean, & Anisko, 2014). It is hardy to USDA Zone 5 (Bean, & Anisko, 2014). *C. spicata* is not listed as being of conservation concern.

The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections. A total of four of the accessions in the BGCI Collections Survey were of wild collected, and these were all reported from Shikoku Island, Japan. It is also interesting that the BGCI Institution Report would report fewer institutions and countries than the BGCI Collections Survey. This is due to BGCI extending the invitation to submit data to more institutions than initially reported to the standard Institution Report.

Table 13 *Corylopsis spicata*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis spicata</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	33	47
Countries	7	14
Accessions	N/A	151
Wild Provenance	N/A	4
Plants	N/A	253

### 2.2.20 *Corylopsis stelligara* Guillaumin

Original Publication: Notul. Syst. (Paris). 3: 25. 1914

The Flora of China lists the common name of *C. stelligara* “星毛蜡瓣花” or “xing mao la ban hua.” The Plant List 1.1 lists *C. stelligara* as a synonym to *C. henryi*, but the Flora of China lists both as unique species and outlines differences between the two. The differences include; habit, stem pubescence, size of terminal bud, size of leaf, number of vein pairs, petiole pubescence, petal size, pubescence of floral cup, pubescence of ovary, fruiting period, and seed size (Flora of China, n.d.). *C. stelligara* is a shrub or small tree with young stems that are gray-brown, pubescent and lenticellate (Flora of China, n.d.). The terminal buds are glabrous, ellipsoid, and 1.5-2 cm long (Flora of China, n.d.). Due to the many differences between the species, they are treated as separate species in this thesis.

The leaves of *C. stelligara* are obovate or obovate-elliptic, 5-12 cm long, and 3-7 cm wide (Flora of China, n.d.). The leaves are a similar shape to *C. henryi* but are larger. The margin is serrate towards the apical half of the leaf, and individual teeth are mucronate (Flora of China, n.d.). The base is cordate and asymmetrical, and the apex is acute (Flora of China, n.d.). *C. stelligara* has fewer vein pairs than *C. henryi*, having just 7-8 pairs on each side with the two most basal veins having tertiary venation (Flora of China, n.d.). The adaxial surface is puberulent long the veins only, and the abaxial surface is pubescent along the veins and uncommonly pubescent all over (Flora of China, n.d.). The petioles are stellately pubescent and 10 mm long, the pubescence is a distinguishing feature of *C. stelligara* (Flora of China, n.d.).

The inflorescence is 3-4 cm long and is subtended by five to six scale-like bracts that are ovate and 1-1.3 cm long (Flora of China, n.d.). The flowers are also subtended by bracts and these are tomentose on both surfaces, ovate, and 3-4 mm long



(Flora of China, n.d.). Bracteoles are pubescent, oblong-lanceolate, and 1.5-2 mm long (Flora of China, n.d.). The petals of *C. stelligara* are spatulate and 5 mm long, shorter than the petals of *C. henryi* (Flora of China, n.d.). The sepals are glabrous, ovate, and have a rounded apex (Flora of China, n.d.). Both the floral cup and the ovary are stellately pubescent, and the ovary is superior (Flora of China, n.d.). *C. stelligara* has styles that are as long as the 6 mm stamens, and stamens that extend from the corolla, and *C. henryi* has styles that are longer than the stamens (Flora of China, n.d.). The peduncle is 1 cm long and has two or three basal leaves (Flora of China, n.d.). The flowering period is April to June (Flora of China, n.d.). The infructescence is 5-6 cm long, stellately pubescent capsules are 6-7 mm long, and the ovoid-ellipsoid seeds are 3-4 mm long (Flora of China, n.d.). The fruiting period is June to August, slightly earlier than that of *C. henryi* (Flora of China, n.d.).

*C. stelligara* is native to southwest China and found in forests at elevations ca. 1,300 m (Flora of China, n.d.). This species is not listed as being of conservation concern by the IUCN Red List. *C. stelligara* was not reported on either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.21 *Corylopsis trabeculosa* Hu & W.C.Cheng**

Original Publication: Bull. Fan Mem. Inst. Biol. n.s., 1: 192 1948.

The Flora of China lists the common name of *C. trabeculosa* as “球江蜡瓣花” or “qui jiang la ban hua.” *C. trabeculosa* is a shrub or small tree growing 2.5-5 m in height (Flora of China, n.d.). Young stems are densely villous and are glandular-pubescent (Flora of China, n.d.). The buds are pale green, ovoid-conical, and held terminally on short shoots (Flora of China, n.d.). *The Flora of China* states that the “leaves are imperfectly known”. The only leaf descriptions located were limited and

state that the number of veins on each side of the midrib is between 10 and 12, and that the petiole is densely villous with glandular pubescence, like the young stems (Flora of China, n.d.). No digitized herbarium vouchers were able to be located for observations.

The inflorescence is 3-8 cm long and holds 20-40 flowers in a dense arrangement (Flora of China, n.d.). Individual petals are oblong-spatulate or ovate spatulate with an obtuse apex (Flora of China, n.d.). Within each flower the petals are not uniform in size, ranging from 4-8 mm long, and 2.5-4.5 mm wide (Flora of China, n.d.). The sepals are also unequal in size, triangular or lanceolate, and 0.5-1.5 mm long (Flora of China, n.d.). Basal bracts are present on both the inflorescence and the individual flowers. There are four bracts per inflorescence that are involucre-like at anthesis, bright yellow, 2-2.8 cm long, and 1.2-1.5 cm wide (Flora of China, n.d.). The floral bracts are yellow, oblong or ovate, have an obtuse or acute apex, and are sometimes three-lobed (Flora of China, n.d.). The lower lobe is 14-16 mm long, and 8-10 mm wide (Flora of China, n.d.). The upper lobe is smaller and not as long (Flora of China, n.d.). Bracteoles are lanceolate or linear, 4-6 mm long, 1-1.5 mm wide, and have an acuminate apex (Flora of China, n.d.). The floral cup and ovary are both densely sericeous (Flora of China, n.d.). The style is 1.5-2 mm long, stigmas green and two-parted near the base with the apical portion of the stigma divergent and curving slightly (Flora of China, n.d.). There are five stamens per flower, and these are yellow, ovoid, and 0.5-0.8 mm long (Flora of China, n.d.). The filaments are yellow-green in color, 1.8-2.2 mm long, and inflated at the base (Flora of China, n.d.). The flowering period is from January to March (Flora of China, n.d.). The infructescence is 8-9 cm

long, holds 25-40 capsules, and the fruiting period is from May to September (Flora of China, n.d.). The Flora of China states that the fruits are “imperfectly known”.

*C. trabeculosa* is native to northwest Yunnan Province in China (Flora of China, n.d.). It is found in broadleaved evergreen forests in valleys, slopes, and thickets at elevations between 1,300 and 2,000 m (Flora of China, n.d.). This species is not listed as being of conservation concern by the IUCN Red List. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections. The single institution reported below is in China.

[Table 14 *Corylopsis trabeculosa*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis trabeculosa</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

### 2.2.22 *Corylopsis veitchiana* Bean

Original Publication: Bot. Mag. 136: t. 8349 1910.

The Flora of China lists the common name of *C. veitchiana* as “红药蜡瓣花” or “hong yao la ban hua.” *C. sinensis* f. *veitchiana* (Bean) B.D. Morley & J.M. Chao is a synonym of *C. veitchiana* (The Plant List 1.1., n.d.). The specific epithet is in honor of Victorian horticultural firm, Veitch and Sons, that collected and introduced many plants into the trade in the 19<sup>th</sup> Century (Weaver, 1976). *C. veitchiana* is a shrub with

glabrous young stems that mature to be dark brown and lenticellate (Flora of China, n.d.). The buds are pubescent and ellipsoid (Flora of China, n.d.).

The leaves are obovate or elliptic, 5-10 cm long, and 3-6 cm wide (Flora of China, n.d.). The margin is serrate and individual teeth are mucronate (Flora of China, n.d.). The leaf base is cordate and asymmetrical, and the apex is acute (Flora of China, n.d.). There are 6-8 lateral veins on each side of the midrib, and the two basal veins have tertiary venation (Morley, & Chao, 1977). The adaxial surface is glabrous, and the abaxial surface is gray in color, glabrous, and can be pubescent along the veins (Flora of China, n.d.). The petiole is glabrous and 5-8 mm long (Flora of China, n.d.). The stipules are oblong-lanceolate and 2.2-2.5 cm long (Flora of China, n.d.).

The inflorescence is 3-4 cm long raceme subtended by two to four basal bracts that are ovate or rounded and 1-1.3 cm long (Flora of China, n.d.). Abaxially, these bracts are pubescent (Flora of China, n.d.). Each flower is also subtended by bracts (Flora of China, n.d.). The floral bracts are tomentose, ovate, and 5-6 mm long (Flora of China, n.d.). The bracteoles are pubescent and oblong (Flora of China, n.d.). The sepals are also pubescent and ovate with a rounded apex (Flora of China, n.d.). The petals are spatulate, 5-6 mm long, and 3-4 mm wide (Flora of China, n.d.). The floral cup is stellately pubescent (Flora of China, n.d.). The ovary is stellately tomentose and is adnate to the floral cup (Flora of China, n.d.). The styles are 5-6 mm long, and the stamens are slightly exerted from the corolla with red anthers (Flora of China, n.d.). The peduncle pubescent, 1-1.2 cm long, and has one to two basal leaves (Flora of China, n.d.). The pedicel is also pubescent (Morley, & Chao, 1976). The flowering period is from April to June, and buds are frequently killed by spring frosts (Flora of China, n.d.; *Corylopsis*, 1920). The infructescence is 5-6 cm long and holds stellately

pubescent capsules that are 7-8 mm long (Flora of China, n.d.). The seeds are 4-5 mm long, and the fruiting period is June to August (Flora of China, n.d.).

*C. veitchiana* is native to the Anhui, Hubei, and Sichuan Provinces in China (Flora of China, n.d.). It is found in forests at elevations ca. 1,200 m (Flora of China, n.d.). This species is not listed as being of conservation concern by the IUCN Red List. There are 32 accessions of *C. veitchiana* reported in the BGCI data set. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 15 *Corylopsis veitchiana*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis veitchiana</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	41	15
Countries	12	8
Accessions	N/A	32
Wild Provenance	N/A	1
Plants	N/A	52

### 2.2.23 *Corylopsis velutina* Hand.-Mazz.

Original Publication: Anz. Akad. Wiss. Wien, Math.-Naturwiss. Kl. 62: 130 1925.

The Flora of China lists the common name of *C. velutina* as “绒毛蜡瓣花” or “rong mao la ban hua.” *C. velutina* is a shrub that grows to 3 m in height (Flora of China, n.d.). Young stems are glabrescent or tomentose and mature to be grayish-brown and lenticellate (Flora of China, n.d.). The buds are glabrous and elliptic (Flora of China, n.d.).

The leaves are ovate-rounded or rounded, 5-9 cm long, and 3-5.5 cm wide (Flora of China, n.d.). The margin is serrate and the teeth are shortly mucronate (Flora of China, n.d.). The base is cordate and asymmetrical, and the apex is subacute (Flora of China, n.d.). There are eight to nine veins on each side of the midrib, the two basal veins have indistinct tertiary venation (Flora of China, n.d.). The abaxial surface is stellate pubescence with brown, villous, hairs only on the veins (Flora of China, n.d.). The petiole is 1.5-2 cm long (Flora of China, n.d.). The stipules are the same length with a rounded apex, have pubescence on the abaxial surface, and are villous adaxially (Flora of China, n.d.).

The inflorescence is 3-4 cm long with rounded basal bracts that are pubescent and 1-1.2 cm long (Flora of China, n.d.). The flowers also have basal bracts, and these are tomentose (Flora of China, n.d.). Tomentose bracteoles are present and lanceolate in shape (Flora of China, n.d.). The sepals can be glabrous or ciliate, are ovate and 0.8-1 mm long (Flora of China, n.d.). The petals are spatulate, 3-4 mm long, and 3-4 mm wide (Flora of China, n.d.). The floral cup is pubescent, and the ovary is tomentose (Flora of China, n.d.). The styles are 1.2-1.5 mm long, and the stamens are 2-3 mm long (Flora of China, n.d.). The peduncle is 0.8-1 cm long with dense tomentose pubescence, and two or three basal leaves (Flora of China, n.d.). The flowering period is April to June (Flora of China, n.d.). The infructescence is 4-6 cm long, tomentose capsules are 6-8 mm long, and the seed are 4-5 mm long (Flora of China, n.d.). The fruiting period is June to August (Flora of China, n.d.).

*C. velutina* is native only to the Sichuan Province in China (Flora of China, n.d.). It is found in montane forests at elevations between 1,000 and 1,200 m (Flora of China, n.d.). *C. velutina* is not listed as being of conservation concern by the IUCN

Red List. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.24 *Corylopsis willmottiae* Rehder & E.H.Wilson**

Original Publication: Pl. Wilson. 1: 425 1913.

The Flora of China states that the common name of *C. willmottiae* is “四川蜡瓣花” or “si chuan la ban hua.” This species was described and introduced by Ernest Henry Wilson in 1908 (Dirr, 1998). *C. willmottiae* is uncommon in the trade, but it was present in both the BGCI data set and the Global Gardens Data Set (Dirr, 1998). *C. willmottiae* is a shrub that grows to 5 m in height (Flora of China, n.d.). Young stems are glabrous and slender, and mature branches have small white lenticels (Flora of China, n.d.). The buds are glabrous and narrowly ovoid (Flora of China, n.d.).

The leaf is obovate or broadly obovate, 4-9 cm long, and 2-6 cm wide (Flora of China, n.d.). The leaf margin is sinuate-dentate, and the individual teeth are mucronate (Flora of China, n.d.). The base is subcordate or truncate, and the apex is acute or short acuminate (Flora of China, n.d.). There are seven to nine veins on each side of the midrib, and the two basal veins have indistinct tertiary venation (Flora of China, n.d.). Morley, & Chao state that there is tomentose pubescence on the veins (1977). The adaxial surface is glabrous and bright green and abaxially the leaves are glabrescent, glaucous, and the veins have downy pubescence (Flora of China, n.d.; Dirr, 1998). Morley, & Chao (1977) describe the petioles as being tomentose-pubescent, but the Flora of China states the petioles are glabrous and 10-15 mm long. The stipules are oblong, 1.2-2 cm long, and purple in color (Flora of China, n.d.).

The inflorescence is a 7.5-10 cm long raceme with 12-20 flowers per inflorescence (Bean, & Anisko, 2014; Flora of China, n.d.). The inflorescence of *C.*

*willmottiae* seems to be the longest of the *Corylopsis* (Bean, & Anisko, 2014). The inflorescence is held on terminal shoots and has ovate-rounded basal bracts that are 1-1.5 cm long (Flora of China, n.d.). These bracts are glabrous on the abaxial surface (Flora of China, n.d.). Each flower is subtended by bracts that are 6-8 mm long and 3-4 mm wide (Flora of China, n.d.). Bracteoles are 2-3 mm long, 1.5-2 mm long, and pubescent on both surfaces (Flora of China, n.d.). The sepals are glabrous, 1.2-1.5 mm long, and ovate with a rounded apex (Flora of China, n.d.). The petals are broadly obovate with a clawed base, 3-4 mm long, and 2.5-3 mm wide (Flora of China, n.d.). The floral cup and ovary are both glabrous (Flora of China, n.d.). The styles are 3-4 mm long, and the stamens are 2.5-3 mm long (Flora of China, n.d.). The peduncle is tomentose, 1-2 cm long, and has one to three basal leaves (Flora of China, n.d.). The flowering period is from March to June (Flora of China, n.d.). The infructescence is 4-5 mm long, capsules are 7-8 mm long, and seeds are ca. 4 mm long (Flora of China, n.d.). The capsules are more than halfway enclosed in the persistent floral cup, the styles are also persistent and are distinctly curved (Flora of China, n.d.). The fruiting period is from June to August (Flora of China, n.d.).

*C. willmottiae* is native to western Sichuan Province in China (Flora of China, n.d.). It is found in forests at elevations ca. 1,200 m (Flora of China, n.d.). *C. willmottiae* is hardy to USDA Zone 6 (Dirr, 1998). This species is not listed as being of conservation concern by the IUCN Red List. The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections. All wild provenance accessions are reported from Sichuan Province, China.



Table 16 *Corylopsis willmottiae*: BGCI Institution Report and BGCI Collections Survey

<i>Corylopsis willmottiae</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	35	16
Countries	14	8
Accessions	N/A	36
Wild Provenance	N/A	9
Plants	N/A	56

### 2.2.25 *Corylopsis yui* Hu & W.C.Cheng

Original Publication: Bull. Fan Mem. Inst. Biol. n.s., 1: 193 1948.

The Flora of China lists the common name of *C. yui* as “长穗蜡瓣花” or “chang sui la ban hua.” Young stems are pubescent with gray-brown hairs and mature branches dry to dark brown and are lenticellate (Flora of China, n.d.). The buds are pubescent, narrowly ovoid, and 1-1.2 cm long (Flora of China, n.d.). The leaves are obovate or obovate-rounded, 7-13 cm long, and 4-10 cm wide (Flora of China, n.d.). The leaf margin is serrate, and the individual teeth are clearly mucronate (Flora of China, n.d.). The base is subcordate or rounded and asymmetrical, and the apex is acute (Flora of China, n.d.). There are 8-11 veins on each side of the midvein, the two basal veins have tertiary venation (Flora of China, n.d.). The adaxial surface is glabrous, and abaxially the leaves are pubescent (Flora of China, n.d.). The petiole is pubescent and 8-17 mm long (Flora of China, n.d.). The stipules are narrowly oblong, 16-18 mm long, and 3-4 mm wide (Flora of China, n.d.). The adaxial surface is villous, and the abaxial surface has gray pubescence (Flora of China, n.d.).

The inflorescence is a raceme that is held on terminal shoots (Flora of China, n.d.). There are four to five basal bracts on the inflorescence (Flora of China, n.d.). Each bract is ovate, ca. 1.2 cm long, adaxially villous, and abaxially pubescent (Flora of China, n.d.). The individual flowers have floral bracts which are also ovate, but are tomentose and 4-5 mm (Flora of China, n.d.). Bracteoles are lanceolate and tomentose (Flora of China, n.d.). The ovary is glabrous, and the styles are 1-1.5 mm long (Flora of China, n.d.). The peduncle is villous, 1-1.5 cm long, and has one or two basal leaves (Flora of China, n.d.). The flowering period is March to June (Flora of China, n.d.). The infructescence is 9-12 cm long and holds 9 to 16 capsules (Flora of China, n.d.). Each capsule is shortly pedicellate, glabrous, and 7-8 mm long (Flora of China, n.d.). The styles are persistent and are 1.2-1.5 mm long (Flora of China, n.d.). The seeds are 3-4 mm long and the fruiting period is June to August (Flora of China, n.d.).

*C. yui* is native to northwest Yunnan Province in China and is found in high elevation forests between 2,700 and 3,000 m (Flora of China, n.d.). This species is not listed as being of conservation concern by the IUCN Red List. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.2.26 *Corylopsis yunnanensis* Diels**

Original Publication: Notes Roy. Bot. Gard. Edinburgh 5: 226 1912.

The Flora of China lists the common name of *C. yunnanensis* as “滇蜡瓣花” or “dian la ban hua.” *C. yunnanensis* is a shrub that grows to 3 m (Flora of China, n.d.). Young stems are tomentose and mature to dark brown, glabrescent, and lenticellate (Flora of China, n.d.). The buds are glabrous and oblong (Flora of China, n.d.). The leaves are obovate-rounded, 5-8 cm long, and 3-6 cm wide (Flora of China, n.d.). The margin is serrate with shortly mucronate teeth (Flora of China, n.d.). The

base is cordate and asymmetrical, and the apex is rounded with a deltoid mucronate tip (Flora of China, n.d.). There are 8 veins on each side of the midvein, the two basal veins have obscure tertiary venation (Flora of China, n.d.). The adaxial surface is glabrescent, and the abaxial surface is sericeous with gray stellate pubescence mostly along the veins (Morley, & Chao, 1977; Flora of China, n.d.). The petioles are described as glabrous by Morley, & Chao (1977), but the Flora of China (n.d.) describes the petiole as pubescent and 10-12 mm. The stipules are glabrous and oblong (Flora of China, n.d.).

The inflorescence is a 1.5-2.5 cm long raceme that has ovate-rounded basal bracts (Flora of China, n.d.). These bracts are 1-1.8 cm and glabrous on the abaxial surface (Flora of China, n.d.). The floral bracts are pubescent, ovate-rounded, and 6 mm long (Flora of China, n.d.). The bracteoles are pubescent, lanceolate, and 3-4 mm long (Flora of China, n.d.). Both the floral cup and the ovary have stellate pubescence (Flora of China, n.d.). The styles are pubescent at the base only and 2-2.5 mm long (Flora of China, n.d.). The stamens are 4-5 mm long (Flora of China, n.d.). The peduncle is tomentose, 1-1.2 cm long, and has two basal leaves (Flora of China, n.d.). The flowering period is from April to June (Flora of China, n.d.).

The infructescence is 3.5-4.5 cm long, and the capsules are stellately pubescent (Flora of China, n.d.). The capsules are 6-7 mm long with persistent styles that are 1.8-2 mm long and a moderately curved apex (Flora of China, n.d.). The fruiting period is from June to August (Flora of China, n.d.).

*C. yunnanensis* is native to western Yunnan in China and is found in forests at elevations ca. 1,500 m (Flora of China, n.d.). The IUCN Red List does not list *C.*

*yunnanensis* as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.2.27 *Corylopsis* Cultivars**

Below is a list of cultivar names located for *Corylopsis*. Additional details for each cultivar are in Appendix A of this thesis.

*Corylopsis* ‘Struik I’

*Corylopsis* ‘Struik II-1-groen’

*Corylopsis* ‘Struik II-2 rood’

*Corylopsis* ‘Winterthur’

*Corylopsis glabrescens* ‘Cholipo’

*Corylopsis glabrescens* ‘Lemon Drop’

*Corylopsis glabrescens* ‘Longwood Chimes’

*Corylopsis gotoana* ‘March Jewel’

*Corylopsis himalayana* ‘Winter Glow’

*Corylopsis pauciflora* ‘Red Leaf’

*Corylopsis sinensis* ‘Hemelrijk’

*Corylopsis sinensis* ‘Spring Purple’

*Corylopsis sinensis* ‘Tosa Kasumi’

*Corylopsis spicata* ‘Aurea’

*Corylopsis spicata* ‘Golden Spring’

*Corylopsis spicata* ‘Ogon’

*Corylopsis spicata* ‘Red Eye’

### 2.3 *Dicoryphe* Overview

**Nomenclature and Taxonomy:** The genus *Dicoryphe* was first described in 1804 and was one of the first four genera conscripted within the Hamamelidaceae by Brown in 1818 (Li, Bogle, & Klein, 1999). The literature supports including *Dicoryphe* in the subfamily Hamamelidoideae and the tribe Dicoryphinae (Li, Bogle, and Klein, 1999). Endress (1989) proposed the subtribe Dicoryphinae, which included *Dicoryphe*, *Trichocladus*, *Ostrearia*, *Neostrearia*, and *Noahdendron*, but this was not strongly supported by the ITS analyses of Li, Bogle, and Klein (1999), stating that more research needed to be completed to resolve the taxonomy. Parsimony analysis by Magallón (2007) supports the subtribe Dicoryphinae as described by Endress (1989). Although Magallón was not able to include *Neostrearia* in their analysis. All species of *Dicoryphe* are endemic to Madagascar (Lourenço, & Rakotobe, 1996). The Malagasy name for it is “pitsikala” which literally translates to “something that escapes by jumping”, this is in reference to the dehiscent seed (Lourenço, & Rakotobe, 1996).

*The Plant List 1.1* recognizes 13 species of *Dycoryphe*. The *Catalogue of the Plants of Madagascar*, and online resource through *Tropicos*, estimates a total of 18 species, but currently only accepts six valid species names. Presently the entries for *Dicoryphe* in *Catalogue of the Plants of Madagascar* are being revised by E. Rakotobe, P. Lowry, G.E. Schatz, and L. Andriamahefarivo. All the taxa that *The Plant List 1.1* recognizes as accepted are listed here as such. Species descriptions were difficult to find in the literature for all species. Descriptions of *Dicoryphe* relied heavily on personal observations of digitized herbarium vouchers and some photos with verified identification. No cultivars of *Dicoryphe* were found in the literature.

**Description:** The filaments are at least partially fused, and the style is syncarpic, both features distinguish *Dicoryphe* from other genera in the Hamamelidaceae (Lourenço, & Rakotobe, 1996). Presence of a defined pedicel is uncertain in *Dicoryphe* according to Magallón (2007), but was apparent on observed digitized herbarium vouchers. Flowers are four-merous, with tubular calix and are held in clusters terminally on short shoots (Lourenço, & Rakotobe, 1996). Flowers can be white, yellow, red, purple, or crimson (Lourenço, & Rakotobe, 1996). Petals are ribbon-like, but are not coiled circinately in bud like other members of the family with similar petal shape (Li, & Bogle, 2001).

All species of *Dicoryphe* are endemic to Madagascar (Lourenço, & Rakotobe, 1996). No species of *Dicoryphe* are listed by the IUCN Red List. No species of *Dicoryphe* were reported in either BGCI data set.

### **2.3.1 *Dicoryphe angustifolia* Tul.**

Original Publication: Ann. Sci. Nat., Bot. IV, 8: 145 1857.

*D. angustifolia* is an aquatic shrub (Tropicos, 2016). *D. angustifolia* is found in the Toamasina Province of Madagascar in wetlands and fast-moving freshwater (Tropicos, 2016). It grows at elevations between 0 and 999 m (Tropicos, 2016). This species is not listed by the IUCN Red List, but is only reported in two to five localities (Tropicos, 2016). The exact number of individuals within each locality is unclear, but it does warrant further investigation to verify that it is not of conservation concern. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### 2.3.2 *Dicoryphe buddleoides* Baker

Original Publication: J. Bot. 20: 111 1882

An image of *D. buddleoides* was accessed through the *Tropicos* image search (Schatz, & Missouri Botanical Garden, 1996). This image shows thick leaves with a broadly acute leaf base and appears to show dense pubescence on the stems and petioles. On the adaxial surface veins do not appear to be raised (Schatz, & Missouri Botanical Garden, 1996).

A digitized type specimen was also observed through the online herbarium catalogue of the Royal Botanic Gardens, Kew. The specimen, K000075917, was collected by Richard Baron (collector number 125) in “Betseileo-land”, Madagascar. The date of collection was not recorded, but the voucher notes state it was received into Richard Baron’s collection in July 1880. The leaves from this specimen were observed to be narrowly elliptic, with an entire margin, acute base, and acute to acuminate apex (Baron K000075917, n.d.). Leaves measured from the voucher are ca. 5-8.5 cm long and ca. 1.5-3.5 cm wide. Petioles were measured to be 3-6 mm long (Baron K000075917, n.d.).

The image accessed via the *Tropicos* image search showed crimson red flowers, each with four petals, and held in clusters at the tip of a short shoot (Schatz, & Missouri Botanical Garden, 1996). Notes from the type specimen state that there are four stamens and that the flower is polypetalous (Baron K000075917, n.d.).

*D. buddleoides* is found in the Antananarivo and Fianarantsoa Provinces in Madagascar. It grows in humid montane forests at elevations between 1,000 and 2,499 m (Tropicos, 2017 December). *Tropicos* (2017 December) lists that *D. buddleoides* is found in more than five localities. This species is not listed by the IUCN Red List.

This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.3 *Dicoryphe gracilis* Tul.**

Original Publication: Ann. Sci. Nat., Bot. IV, 8: 144 1857

It is accepted by *The Plant List 1.1*, and since that was the primary resource used for naming conventions it is listed as accepted in this thesis. However, it is considered a synonym of *D. stipulacea* by the *Catalogue of the Plants of Madagascar* (Tropicos, 2009c). Due to the lack of any additional descriptions or specimens, it is recommended that further research be completed on this name. This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.4 *Dicoryphe guatteriifolia* Baker**

Original Publication: J. Linn. Soc., Bot. 22: 473 1887

*The Plant List 1.1* lists *D. guatteriifolia* as an accepted species name, but the *Catalogue of the Plants of Madagascar* lists it as a synonym to *D. laurina* (Tropicos, 2017 January). The Herbarium Catalog of the Royal Botanic Gardens, Kew do recognize this as an accepted species name, and the digitized type specimen was observed (K000075909). This specimen was also collected by Richard Barron (collector number 4940), and again no collection date was recorded, but the voucher notes state that it was received into Baron's collection in 1885. The leaves of this specimen were observed to be ovate to elliptical, with a broadly acute to rounded base, and a rounded apex (Baron K000075909, n.d.). The margin is entire, and the midvein is distinctly indented on the adaxial surface (Baron K000075909, n.d.). The leaf



dimensions were measured to be ca. 3-5 cm long, ca. 1.5-3.5 wide, and the petiole was ca. 0.5-1 cm long (Baron K000075909, n.d.).

This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.5 *Dicoryphe lanceolata* Tul.**

Original Publication: Ann. Sci. Nat., Bot. IV, 8: 146 1857

*D. lanceolata* is a shrub or tree (Tropicos, 2009a). *D. lanceolata* is found only in the Antsiranana Province in Madagascar (Tropicos, 2009a). It grows in “sub-humid” forests at elevations between 0 and 499 m (Tropicos, 2009a). *D. lanceolata* is only known from two to five localities (Tropicos, 2009a). This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.6 *Dicoryphe laurifolia* Baker**

Original Publication: J. Linn. Soc., Bot. 22: 474 1887

Although, *The Plant List 1.1* lists *D. laurifolia* as an accepted species, the *Catalogue of the Plants of Madagascar* lists it as a synonym to *D. laurina* (Tropicos, 2017b). The online Herbarium Catalogue of the Royal Botanic Gardens, Kew does recognize *D. laurifolia* as a valid name, and two digitized vouchers were observed for the species description. The specimens were both collected by Richard Baron, no collection date was recorded, and both specimens are mounted on the same sheet, but retain different accession numbers; K000075913 and K000075914. Baron used the same collector number, 4941, for both specimens. The leaves from the two specimens were observed to be elliptical, with an acute base, and the apex can be acute,

acuminate with a rounded tip (Baron K000075913, K000075914, n.d.). The leaves are ca. 3-8 cm long and ca. 1.5-5 cm wide (Baron K000075913, K000075914, n.d.). The midvein appears recessed on the adaxial surface and raised abaxially (Baron K000075913, K000075914, n.d.). The petioles are distinctly short and ca. 3-7 mm long (Baron K000075913, K000075914, n.d.). Capsules are also present on both specimens. These are oblong, ca. 1.5 cm long, with a pointed apex, and held on a pedicel that is ca. 0.4 mm long (Baron K000075913, K000075914, n.d.). On K000075913 the capsules are retained on the specimen and clustered terminally in a group of three (Baron, n.d.). This species was not reported on the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.7 *Dicoryphe laurina* Baill.**

Original Publication: Bull. Mens. Soc. Linn. Paris 1: 476 1885

*D. laurina* is a shrub (Tropicos, 2017b). The online Herbarium Catalogue of the Royal Botanic Gardens, Kew has two specimens of *D. laurina*. One is a type specimen, K000075916, and is mounted on the same sheet as an isotype K000075915. Both were collected by M. Humblot under the collector number 615. M. Humblot's full name was not able to be located for this thesis. The *International Plant Names Index* lists a "Leon Humblot", but he was a collector only in France and the Comoros, with no mention of nearby Madagascar. No collection date was recorded, but a voucher note states that it was received in October 1883. The leaves on the two specimens are ovate, elliptic, or obovate, and all with an entire margin. The base is mostly acute but can be rounded or almost truncate (Humblot K000075915, K000075916, n.d.). The leaf dimensions were measured to be ca. 3.5-6 cm long, ca.

1.5-4.5 cm wide, and the petiole was ca. 0.0-0.7 mm long (Humblot K000075915, K000075916, n.d.). The flowers appear to be spent or just emerging on both specimens, and these are clustered terminally on shoots that are ca. 2 cm long (Humblot K000075915, K000075916, n.d.).

*D. laurina* is found in Antananarivo, Antsiranana, Fianarantsoa, Toamasina, and Toliara Provinces in Madagascar (Tropicos, 2017b). It grows in humid to sub-humid forests at elevations between 0 and 1,499 m (Tropicos, 2017b). *D. laurina* is reported in more than five localities (Tropicos, 2017b).

This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.8 *Dicoryphe macrophylla* Baill.**

Original Publication: Bull. Mens. Soc. Linn. Paris 1: 476 1885

*D. macrophylla* is described as a tree (Tropicos, 2009b). Three digitized herbarium vouchers were located of *D. macrophylla* using the online Herbarium Catalog through the Royal Botanic Gardens, Kew. These three specimens were each collected by M. Humblot, under the collector number 540, and no collection date was recorded. Notes on the vouchers indicate that they were received in “18?2” (the written date on this specimen being indecipherable) (K000075911), 1883 (K000075912) and 1892 (K000075910). The leaves are broadly elliptic or broadly ovate. The leaves were measured to be ca. 16-24 cm long and ca. 8-11 cm wide, this was the largest leaf measured in the genus. The apices of the specimens were almost all missing, one leaf apex appeared acute (Humblot K000075910, n.d.), and two appeared emarginate (Humblot K000075911, K000075912, n.d.). It is unclear if the emarginate characteristic is due to decay or true representation of the species. The leaf

base is frequently rounded but can broadly acute (Humblot K000075910, K000075911, K000075912, n.d.). The lamina appears to be coriaceous in all of the specimens observed (Humblot K000075910, K000075911, K000075912, n.d.).

An image observed through the *Tropicos* image search shows that the leaves are petiolate, and stipules are present (Schatz, & Missouri Botanical Garden, 1990). No scale bar was present in the photo. The stipules in the photo are broadly ovate with a rounded to acuminate apex (Schatz, & Missouri Botanical Garden, 1990).

The photo accessed through *Tropicos* also shows a close-up of the flowers of *D. macrophylla* (Schatz, & Missouri Botanical Garden, 1990). The flowers appear creamy-white in the image, most flowers show four petals (Schatz, & Missouri Botanical Garden, 1990). The image shows a tubular calyx with mostly fused sepals (Schatz, & Missouri Botanical Garden, 1990). Flowers are held on short axillary shoots and are clustered at the tips of these with sporadic flowers along the shoot (Schatz, & Missouri Botanical Garden, 1990).

*D. macrophylla* is found in the Antsiranana and Toamasina Provinces in Madagascar (Tropicos, 2009b). It grows in humid or sub-humid forests at elevations between 0 and 999 m (Tropicos, 2009b). This species is not listed by the IUCN Red List. This species was not reported in either the BGCi Institution Report or the BGCi Collections Survey.

### **2.3.9 *Dicoryphe noronhae* Tul.**

Original Publication: Ann. Sci. Nat., Bot. IV, 8: 147 1857

Synonyms of *D. noronhae* are *Diana amplifolia* Noronha ex Tul. and *Schizolaena noronhae* (Tul.) G.E. Schatz & Lowry (The Plant List 1.1, n.d.). Although *The Plant List 1.1* accepts the species name *D. noronhae*, the *Catalogue of the Plants*

of Madagascar recognize the synonym *Schizolaena noronhae* as accepted, and they place that within the Sarcolaenaceae within the Malvales (Tropicos, 2019). It is unclear what causes this great discrepancy in the literature.

This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.10 *Dicoryphe platyphylla* Tul.**

Original Publication: Ann. Sci. Nat., Bot. IV, 8: 146 1857

*D. platyphylla* was not listed in the *Catalogue of the Plants of Madagascar*. A vouchered specimen was located through the online database of the Muséum National D'Historie Naturelle in France. This online entry also included verified photos of living specimens of *D. platyphylla*. The voucher was collected on November 11, 2000 by J.N. Labat and colleagues. The photos connected with this online entry are also credited to J.N. Labat. Notes from this voucher state that the specimen was a 15 m tree with a diameter at breast height of 80 cm (Labat MNHN-P-P00209716, 2000). Observations of the herbarium voucher showed that the leaf of *D. platyphylla* is narrowly elliptic with an acute base, and an acute to acuminate apex (Labat MNHN-P-P00209716, 2000). The dimensions of the leaf were unable to be measured as no scale bar was included in the digitized voucher. The petiole appears longer in this species than in others, but that was not able to be verified without a scale bar. Observations were made of the flower from both photos and of a preserved flower in silica gel enclosed with the digitized specimen. The flower is four-merous and white, with thick, yellow stamens. The sepals are partly fused, yellow-green in color, elongated and cup the petals (Labat MNHN-P-P00209716, 2000). Voucher notes confirm that the flower is four-merous, the calyx is green and tubular, and state that the stamens are “short and

central” (Labat MNHN-P-P00209716, 2000). The notes also state that there are four to five flowers per “pseudoglomerule” inflorescence (Labat MNHN-P-P00209716, 2000).

Notes from the herbarium specimen state that *D. platyphylla* is found in “dense humid forests” at elevations between 100 and 200 m (Labat MNHN-P-P00209716, 2000). This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.11 *Dicoryphe retusa* Baker**

Original Publication: J. Linn. Soc., Bot. 22: 473 1887

*D. retusa* is listed as a synonym of *D. laurina* in the *Catalogue of the Plants of Madagascar*, but is listed by *The Plant List 1.1* as accepted (Tropicos, 2017). The online Herbarium Catalogue of the Royal Botanic Gardens, Kew has one digitized type specimen of this taxon. This specimen was collected by Richard Baron under the collector number 4408 (Baron K000075908, n.d.), and no collection date was recorded. A note on the voucher states that it was received in December 1885. The leaves on this specimen are elliptic or oblong with an entire margin (Baron K000075908, n.d.). The base is broadly acute, rounded or obtuse, and the apex is acute or rounded (Baron K000075908, n.d.). The leaves were measured to be ca. 4-7 cm long and ca. 1.5-3 cm wide (Baron K000075908, n.d.). The petioles were measured to be ca. 2-5 mm long (Baron K000075908, n.d.). The voucher is of a flowering specimen, and the flowers are held terminally on short shoots in clusters (Baron K000075908, n.d.).

This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.12 *Dicoryphe stipulacea* J. St.-Hil.**

Original Publication: Expos. Fam. Nat. 2: 348 1805

*D. stipulacea* is the type of the genus *Dicoryphe* (Tropicos, 2009d). Synonyms of *D. stipulacea* are *D. madagascariensis* Poir. and *D. thouarsii* Roem. & Schult. (The Plant List 1.1, n.d.). *D. stipulacea* can be a shrub or tree (Tropicos, 2009d).

The *Tropicos* image search was used to locate an image of the leaf of *D. stipulacea* (Schatz, & Missouri Botanical Garden, 1994). Although no scale bar was included in the image to determine size, the leaf shape was observed to be elliptic to narrowly elliptic, with an acute apex, entire margin, and acute to rounded leaf base (Schatz, & Missouri Botanical Garden, 1994).

The *Tropicos* image also showed the fruit of *D. stipulacea* (Schatz, & Missouri Botanical Garden, 1994). The fruit is an elliptic capsule that splits loculicidally along one axis (Schatz, & Missouri Botanical Garden, 1994). The apex of the capsule comes to a point and shows an attachment scar where the petals were presumably attached (Schatz, & Missouri Botanical Garden, 1994).

*D. stipulacea* grows in the Antisiranana and Toamasina Provinces in Madagascar (Tropicos, 2009d). It is found in humid forested habitats at elevations between 0 and 499 m (Tropicos, 2009d). This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.3.13 *Dicoryphe viticoides* Baker**

Original Publication: J. Linn. Soc., Bot. 20: 143 1883

Although, *The Plant List 1.1* lists *D. viticoides* as an accepted name, the *Catalogue of the Plants of Madagascar* list it as a synonym of *D. buddleoides*

(Tropicos, 2017). Two herbarium vouchers were accessed through the online Herbarium Catalogue of the Royal Botanic Gardens, Kew. Both of the specimens were collected in 1881 in central Madagascar, but no collector is recorded. The specimen K000075906 is a type specimen, and the specimen K000075907 is of unknown type material. The notes on both of the specimens state that the ovary is inferior and the seed is two-locular (No Collector K000075906 & K000075907, 1881). From observations of the type specimen, the leaves are broadly elliptic, rounded and sometimes oblique at the base, and broadly acute at the apex (No Collector K000075906, 1881). The margin was observed to be entire (No Collector K000075906, 1881). The leaves were measured to be ca. 3.5-10 cm long and ca. 2.5-7 cm wide (No Collector K000075906, 1881). It appears that the flowers are in bud on the type specimen and are clustered at the tips on short shoots in leaf axils (No Collector K000075906, 1881). The presumed flower buds are covered in dense yellow-brown pubescence (No Collector K000075906, 1881). The stems are green with, what appears to be, white lenticels (No Collector K000075906, 1881). The second voucher observed, K000075907, 1881, demonstrates the same characteristics described here, but the leaf size is in the smaller range of what is given above. Although it is difficult to provide accurate descriptions from digitized herbarium specimens, it is hoped that future researchers with access to live material can compare and publish their observations to verify the accuracy of the above observations.

This species is not listed by the IUCN Red List. This species was not reported in either the BGCI Institution Report or the BGCI Collections Survey.



## 2.4 *Disanthus* Overview

**Nomenclature and Taxonomy:** The genus *Disanthus* was first described by Russian botanist, Carl Johann Maximowicz, in 1866 (Averyanov, Endress, Quang, Nguyen, & Van, 2017). The name is in reference to the paired flowers placed oppositely on the flower spikes of the first species described in this genus (Averyanov et al., 2017). *Disanthus* is the only genus in the subfamily Disanthoideae, and until recently was considered a monospecific genus (Magallón, 2007; Averyanov et al., 2017). Presently, the literature supports two species of *Disanthus*, but there is debate if the newest species described, *Disanthus ovatifolius*, is in fact a new genus, *Uocodendron*. Further discussion on this topic is in the species discussion of *D. ovatifolius*. At the end of the species descriptions is a list of cultivar names located for *Disanthus*. Additional details for each cultivar are in Appendix A of this thesis.

**Description:** *Disanthus* is a tree or shrub, and is either evergreen or deciduous (Manchester, Chen, Lu, & Uemura, 2009; Averyanov et al., 2017). The native range of the genus extends from southeast China, Japan, and parts of Vietnam (Manchester, Chen, Lu, & Uemura, 2009; Averyanov et al., 2017).

### 2.4.1 *Disanthus cercidifolius*

Original Publication: Maximowicz, Bull. Acad. Imp. Sci. Saint-Pétersbourg. 10: 485. 1866.

Common names for this species include long-stiped *Disanthus*, and redbud hazel (RHS Plant Search, n.d.; Great Plant Picks, 2018). The specific epithet is in reference to the similarity of leaf shape to that of *Cercis* sp. (Fischer, 2000). *Disanthus cercidifolius* is present in cultivation, but still unusual. In the United States, it can be found in the nursery trade. A brief internet search found nurseries that offer it for sale,

the first three results from this search were; E.C. Browns' Nursery in Thetford Center, Vermont, Broken Arrow Nursery in Hamdem, Connecticut, and Behmerwald Nursery in Schwenksville, Pennsylvania. Additional nurseries do offer it for sale, but are not listed here.

Fischer describes *D. cercidifolius* as an “elegant, open” shrub (2000). It grows to 3 m in height (Averyanov et al., 2017). Stems are described as “brownish” by Zhang et al. with no note about lenticels (2003). A voucher from the Harvard University Herbaria and Libraries clearly shows large lenticels, but this could be exaggerated from preservation (Tschoski 00043417, 1864). Buds are scaled with an acute apex (Flora of China, n.d.).

Leaves are deciduous, with dramatic fall color ranging from orange to purple to red (Fischer, 2000; Averyanov et al., 2017). A specimen from the Steere Herbarium still shows the red fall color (Noshiro et al. 02706580, 1993). In the growing season, the leaves are blue-green in color with a membranous texture (Fischer, 2000; Averyanov et al., 2017). The leaf arrangement is alternate (Fischer, 2000). The leaf blade is broadly ovate to cordate and is 6-10 cm in length and 5-9 cm in width (Wu et al., 2009; Averyanov et al., 2017). The margin is entire, base is slight to deeply cordate and can even be rounded (Wu et al., 2009; Zhang et al., 2003). A possible type specimen at the Steere Herbarium shows that the base can even be truncate (Tschoski 00356125, 1864). The apex is emarginate to obtuse (Zhang et al., 2003). Averyanov et al. state that *D. cercidifolius* is palmately veined with 5-7 veins (2017). Abaxially, leaves are glaucescent (Ōi, 1965). The petiole is long, and stipules are large, linear, and cauducous (Flora of China, n.d.). In young plants, the stipules are large and leaf-like, but in mature plants stipules are small (Ōi, 1965).

Flower color is described as red, purple, or maroon depending on which source is used. The individual flowers are five-merous, with petals that are linear to lanceolate (Ōi, 1965; Flora of China, n.d.). Fischer describes the flowers as “spidery” which leaves no doubt that it is a member of the Hamamelidaceae, and notes that the flowers are also slightly malodorous (2000). Flowers are up to 2 cm across, sessile, and occur opposite each other in pairs on a spiked inflorescence (Averyanov et al., 2017; Flora of China, n.d.). The isotype at the Harvard University Herbaria and Libraries shows the inflorescence characteristics very well (Tschonoski 00043417, 1864). Each floral spike is found on axillary or short lateral branches (Flora of China, n.d.). Floral bracts are hairy, and each flower has five sepals that are 1-1.5 mm in length (Flora of China, n.d.; Zhang et al. 2003).

Flowers are hermaphroditic and self-compatible, and fungus gnats are one of its most important pollinators (Mochizuki, & Kawakita, 2018). This is of note because fungus gnats are a very uncommon pollinator (Mochizuki, & Kawakita, 2018). Flowering period in wild populations is from November to December, and in cultivation in the United States is October (Mochizuki, & Kawakita, 2018; Missouri Botanical Garden, n.d.). *D. cercidifolius* is hypogynous (Flora of China, n.d.). The style length is 1-1.5 mm and is equal to or shorter than the anthers (Flora of China, n.d.; Averyanov et al., 2017). There are five stamens per flower (Flora of China, n.d.).

The peduncle is very short, 0.3 to 2.2. cm in length (Flora of China, n.d.; Zhang et al., 2003). Capsules are hairy, and ovate to broadly ovate with a truncate apex (Averyanov et al., 2017). Capsules are 1.5 to 1.7 cm long and wide, with a longitudinal slit in the capsule that allows for dispersal of the seed which is then carried by wind (Averyanov et al., 2017; Flora of China, n.d.; Ōi, 1965; Zhang et al.,

2003). There are five to six seeds per capsule. Seeds are ellipsoid, 4-7 mm in length, and 3-4 mm in width (Averyanov et al., 2017; Flora of China, n.d.).

*D. cercidifolius* is native to southeast China and Japan (Manchester, Chen, Lu, & Uemura, 2009). It grows along streams in temperate forests (Mochizuki, & Kawakita, 2018). In cultivation, it is best grown in USDA zones 5 to 8 in full sun to partial shade, but protected from harsh sun (RHS Plant Search, n.d.; Fischer, 2000). Soil conditions should be slightly acidic with regular moisture, with soil texture being sandy clay or loam (Fischer, 2000; RHS Plant Search, n.d.). *D. cercidifolius* is not listed as being of conservation concern by the IUCN Red List. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

Table 17 *Disanthus cercidifolius*: BGCI Institution Report and BGCI Collections Survey

<i>Disanthus cercidifolius</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	92	26
Countries	10	8
Accessions	N/A	65
Wild Provenance	N/A	4
Plants	N/A	95

#### 2.4.1.1 *Disanthus cercidifolius* subsp. *longipes* (H.T. Chang) K.Y. Pan

First described as a variety of *D. cercidifolius* by Hung-ta Chang in 1948, it was later reassigned as a subspecies by Kai Yu Pan in 1991 (Xiao, Neog, Xiao, Li, Liu, & He, 2009; The Plant List 1.1, 2012). It is a deciduous shrub that grows 2 to 4 m in height (Xiao et al., 2009). Xiao et al. describe the stems as brown, glabrous and

lenticellate, the lenticellate trait differs from the straight species (2000). Leaves are broadly ovate to rounded and are the same size and shape as the species (Xiao et al., 2009). Adaxially leaves are green and glabrous, and abaxially leaves dry to a gray-white (Xiao et al., 2009). Petioles are very long, 3-5 cm, but it is unclear if this is longer than the species (Xiao et al., 2009).

Like the species, it is pollinated by wind and insects, it is self-compatible and has great out-crossing compatibility (Xiao et al., 2009). Flowers are similar to the species, but the petals are wider at the base, and styles are 1-1.5 mm in length which is much longer than the species (Xiao et al., 2009). The flowering period is from September to November, depending on the population (Xiao et al., 2009). Each flower opens for six to seven days, and the flower pairs on each spike open at the same time (Xiao et al., 2009). Fruiting period is from September to October of the following year, although Xiao et al. state fruiting can start as early as August in some populations (2009; Flora of China, n.d.).

*D. cercidifolius* subsp. *longipes* is native to mixed evergreen and deciduous broad-leaved forests in south China at elevations of 450-1,200 m (Flora of China, n.d.; Puxin, Aihong, Xiaohong, & Hongwn, 2009). A small number of individuals are found in Hunan, Jiangxi, and Zhejiang Provinces in China (Xiao et al., 2009). Due to habitat fragmentation and few individuals in small populations, this subspecies is listed as “Endangered” by the IUCN, and listed as 2<sup>nd</sup> Class Endangered in China (Xiao et al., 2009; Yu, Fan, Shen, Guo, Jin, Cui, & Liao, 2014; Puxin, Aihong, Xiaohong, & Hongwn, 2009). A lack of effective pollinators is also an important factor for its endangered status (Xiao et al., 2009). Despite these classifications it is not presently given priority for protection in its native range (Yu et al., 2014).

[Table 18 *Disanthus cercidifolius* var. *longipes*: BGCI Institution Report and BGCI Collections Survey

<i>Disanthus cercidifolius</i> var. <i>longipes</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	7	1
Countries	2	1
Accessions	N/A	1
Wild Provenance	N/A	1
Plants	N/A	1

#### 2.4.2 *Disanthus ovatifolius* Averyanov et al.

Original Publication: Averyanov, *Phytotaxa*, 308, 1, 104-110. 2017

The Vietnamese common name for this species is “Sừng gỗ nhiều hạt”, literal translation being “fruit like woody horn with many seeds” which is an apt description for the woody capsules (Averyanov et al., 2017). This has only recently been described but carries with it much debate since its original discovery by Bleddyn Winn-Jones, of Crûg Farm Plants, and his local guide, Mr. Uoc, in Y Ty, Vietnam in 2003 (Winn-Jones, B., personal communication, July 13, 2017). Samples and photos were taken during this expedition (Winn-Jones, B., personal communication, July 13, 2017). In 2006, plant material was collected, and with the assistance of a taxonomist from the Royal Horticultural Society, identified as the endangered *Loropetalum subcordatum* (Winn-Jones, B., personal communication, July 13, 2017). In 2007, Bleddyn Winn-Jones, Peter Wharton (Curator of University of British Columbia Botanical Garden), and a taxonomist from the Vietnamese Environment Agency returned to the site to survey this species. On a 2011 trip to the site, Aaron Floden

(Missouri Botanical Garden) accompanied Bleddyn Winn-Jones. From propagating these plants at Crûg Farm Plants and observing them in the field, it was determined that this was a new genus, *Uocodendron* (Winn-Jones, B., personal communication, July 13, 2017). This name is in reference to the original Vietnamese guide, and the specific epithet “*whartonii*” was chosen in honor of the late Peter Wharton (Winn-Jones, B., personal communication, July 13, 2017). This name has yet to be formally published, but plants under this name were introduced by Crûg Farm Plants as early as 2006 (Averyanov et al., 2017).

In 2017, a publication in the journal *Phytotaxa* described this species as another species of *Disanthus*, with the specific “*ovatifolius*” (Averyanov et al., 2017). This publication supersedes the unpublished name *Uocodendron whartonii*. When contacted about this 2017 publication, both Bleddyn Winn-Jones and Aaron Floden stated that they still believe this to be a unique genus within the Hamamelidaceae, and have plans to publish their findings in order to validate their taxonomic assessment (Winn-Jones, personal communication, July 13, 2017; Floden, A., personal communication, November 28, 2018). Outside of taxonomic disagreement, an additional area of discord found in the 2017 publication was the authors creating a new specific epithet for this plant. In the International Code of Botanic Nomenclature, Division II, Chapter II, Article 11.4 it states that when a generic name has changed, preference should be given to the earliest legitimate specific epithet (International Association for Plant Taxonomy, 2006). Although, *Uocodendron whartonii* has yet to be validly published, and the authors of the 2017 publication knowing of that name and that it honors a deceased colleague, it seems to this author appropriate to retain “*whartonii*” regardless of what genus is taxonomically correct.

There is consensus with this plant material regarding its morphological traits. Both the personal communication with Aaron Floden, and the 2017 Averyanov et al. publication reference the same set of morphological features, the difference seems to be in their interpretation (Floden, A., personal communication, November 28, 2018). Averyanov et al. describe it as superficially similar to some aspects of *Hamamelis* and *Loropetalum*, whereas Floden sites similarities closer to *Rhodoleia* (Averyanov et al., 2017; Floden, A., personal communication, November 28, 2018). Additional genetic work on this material at the genus level could provide insights into its correct classification, but at this time the literature supports the name *D. ovatifolius*.

Although there is no evidence of this plant in cultivation, Averyanov et al. state that this species has ornamental potential (2017). *D. ovatifolius* is an evergreen tree that grow to 5 m in height (Averyanov et al., 2017). Young stems are yellowish-green, turn a truer green with age, and regardless of age, stems are lenticillate which can help distinguish it from *D. cercidifolius* (Averyanov et al., 2017 Zhang et al., 2003). Young shoots are the part of the plant that have indumentum, but become glabrous with age (Averyanov et al., 2017). Bark is gray, and buds are ovoid and purple in color (Averyanov et al., 2017).

Leaf arrangement is alternate, and leaves are simple, narrowly ovate, three-veined and have a leathery texture (Averyanov et al., 2017). Leaves are 7-10 cm in length and 3-4.5 cm in width (Averyanov et al., 2017). Sources agree that the leaf margin is entire, and the apex ranges from caudate to acuminate (Averyanov et al., 2017; Zhang et al., 2003). There is some discrepancy in the base of the leaf, Averyanov et al. describe it as cuneate, and Zhang et al. describe it as truncate to rounded (2017; 2003). Leaf venation is pinnate with tertiary veins distinct adaxially



and abaxially (Averyanov et al., 2017). The adaxial surface is dark green and glossy, and the abaxial surface is light green to white and glaucous (Averyanov et al., 2017). Petioles are rigid, “dull green to purple”, and 1-3 cm long (Averyanov et al., 2017; Zhang et al., 2003). Large stipules are paired and lanceolate to narrowly ovate, and are 8-12 mm in length and 2-3 mm in width (Averyanov et al., 2017).

Flowers are dark red, and five-merous occurring in groups of two to five on a 1-3 mm pedicel within a spike inflorescence (Averyanov et al., 2017; Zhang et al., 2003). The inflorescence contains two or more flowers per spike distinguishing it from *D. cercidifolius*. The inflorescence is capitate and located in leaf axils (Averyanov et al., 2017). Petals are ribbon-like and pointed, and are irregularly incurved when in bud (Averyanov et al., 2017). Sepals are ovate and 1-3 mm in length (Averyanov et al., 2017; Zhang et al., 2003). There are five filamentous stamens per flower, and no staminodes (Averyanov et al., 2017). Flowers are hermaphroditic and the flowering period is March to April (Averyanov et al., 2017).

The ovary is semi-inferior, and the style is 0.9-1.2 mm in length which exceeds the length of the anther (Averyanov et al., 2017; Zhang et al., 2003). The semi-woody capsules are held on sturdy peduncles that are 2-4 cm in length (Zhang et al., 2003). Capsules are narrowly ovate with a cornute apex, this is another distinguishing characteristic of *D. ovatifolius* (Averyanov et al., 2017). 4-8 black seeds are found in each capsule, the capsule is two-valved and dehisces the seeds in a ballistic manner (Averyanov et al., 2017; Zhang et al., 2003). Fruiting period is from October to November (Averyanov et al., 2017).

*D. ovatifolius* is described by Averyanov et al. as an “integral element” in its native broad-leaved and mixed evergreen forests in northwestern Vietnam (2017). It is

often found with *Tsuga dumosa* (Averyanov et al., 2017). It is found at elevations between 1,850 and 2,000 m, but not above 2,000 m (Averyanov et al., 2017). This species is usually found in wet places (Averyanov et al., 2017). When the type specimen was collected in 2017, it was noted that the species was locally common in Lao Cair Province (Averyanov et al., 2017). Averyanov et al. recommend that the IUCN Red List Status be “Data Deficient” (2017).

[Table 19 *Disanthus ovatifolius*: BGCI Institution Report and BGCI Collections Survey

<i>Disanthus ovatifolius</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	0	3
Countries	0	3
Accessions	N/A	3
Wild Provenance	N/A	2
Plants	N/A	3

### 2.4.3 *Disanthus* Cultivars

*Disanthus cercidifolius* is the only member of this genus that has cultivars. At the time of this writing, ten unique cultivars were found, but most are only tentatively accepted.

*Disanthus cercidifolius* ‘Ena-Nishiki’

*Disanthus cercidifolius* ‘Gold Leaf’

*Disanthus cercidifolius* ‘Golden Crown’

*Disanthus cercidifolius* ‘Liku’

*Disanthus cercidifolius* ‘Mine No Zausteu’

*Disanthus cercidifolius* ‘Rikiv’

*Disanthus cercidifolius* ‘Rikyu’

*Disanthus cercidifolius* ‘Seiju Yamaguchi’

*Disanthus cercidifolius* ‘Sirakawa-nisiki’

*Disanthus cercidifolius* ‘Yellow Flower’

## 2.5 *Distyliopsis* Overview

**Nomenclature and Taxonomy:** Peter Endress published the genus *Distyliopsis* in 1970 after observing several species of *Sycopsis* that exhibited unique characteristics (Brummitt, & Utteridge, 2003). As the name suggests, *Distyliopsis* also has morphology very similar to the genus *Distylium*. The presence of a floral cup in *Sycopsis* and *Distyliopsis* immediately separates these genera from *Distylium* (Brummitt, & Utteridge, 2003). *Sycopsis* can be distinguished by its lack of a terminal flower on the inflorescence, simple bracts, and the spiral arrangement of flowers within the inflorescence (Brummitt & Utteridge, 2003). *Distylium* and *Distyliopsis* both have a terminal flower on the inflorescence, one bract and paired stipules in lieu of simple bracts, and a distichous arrangement on the inflorescence (Brummitt, & Utteridge, 2003). These three genera combined with *Parrotia*, *Parrotiopsis*, and *Fothergilla* make up the subtribe “Fothergillinae” within the Fothergilleae (Magallón, 2007; Li, Bogle, & Klein, 1999). The Flora of China recognizes five species of *Distyliopsis*, four of which are endemic to China (Flora of China, n.d.). However, *The Plant List* 1.1 sites an additional accepted species, *D. lanata* N.A. Brummitt & Utteridge, which is supported in the literature. No cultivars were located of this genus in the literature.

**Description:** *Distyliopsis* is an evergreen shrub or tree (Flora of China, n.d.). Young stems are covered with stellately tomentose pubescence or peltate scales that are sessile (Flora of China, n.d.). The buds are scaled (Flora of China, n.d.). Leaves are leathery, lanceolate, elliptic or oblong, and most species have an entire margin (Flora of China, n.d.). The base is typically cuneate, but can be rounded or obtuse (Flora of China, n.d.). Venation is always pinnate, and one species, *D. laurifolia*, has the unique characteristic of three prominent basal veins (Flora of China, n.d.). The petioles are consistently short, and the stipules are ovate or elliptic and caducous in all species (Flora of China, n.d.).

Flowers are believed to be wind pollinated due to the absence of petals throughout the genus (Li, & Del Tredici, 2008). Plants are andromonocious and both the male and bisexual flowers are distichously arranged within their inflorescence (Flora of China, n.d.). The inflorescence is a determinate panicle, but flowers are not described for all species. The inflorescence is held in a leaf axil or terminally on short lateral branches. Male flowers are consistently sessile, and bisexual flowers are commonly pedicellate, but can also be sessile. Carpels are greatly reduced in the male flowers. All flowers lack sepals and have three-lobed bracts. The superior ovary is enclosed by the floral cup, and there is one ovule per locule (Flora of China, n.d.). Each theca in the anthers are two-sporangiate, and dehisce longitudinally (Flora of China, n.d.).

The genus is native to China, Laos, Malaysia, and Papua New Guinea (Flora of China, n.d.). The range of *Distyliopsis* overlaps with *Sycopsis* and *Distylium* in southeast China, but it is unclear if populations of these genera intermix (Endress, 1971). No species appear to be common in the horticulture trade, and no institutions

reported *Distyliopsis* in the BGCI Collections Survey. *D. lanata* is the only species in the genus of conservation concern (Brummitt, & Utteridge, 2003).

### 2.5.1 *Distyliopsis dunnii* (J.H. Hemsl.) Endress

Original Publication: Bot. Jahrb. Syst. 90: 30 1970

The Flora of China lists the local common name of *D. dunnii* as “尖叶假蚊母树” or “jian ye jia wen mu shu” (n.d.). Synonyms to this species include *Croton curviflorus* Elmer, and *Sycopsis dunii* Hemsl. (The Plant List 1.1, n.d.). *D. dunnii* is a shrub or small tree growing 3-6 m (Flora of China, n.d.). Both the young stem and petioles have peltate scales, and turn glabrescent with age (Flora of China, n.d.). The leaf arrangement is alternate and distichous (Flora of China, n.d.). Leaves are described as narrowly elliptic by Brummitt, & Utteridge (2003), but the Flora of China describes the leaves as oblong or ovate-oblong and only occasionally oblong-lanceolate (n.d.). The leaf margin is entire, the base is cuneate or sub-obtuse, and the apex is acute or even acuminate (Flora of China, n.d.). There are 6-7 veins on each side of the midrib, and Brummitt, & Utteridge state the lack of prominent secondary veins is a distinguishing characteristic (2003). An additional identification characteristic is that *D. dunnii* only has stellate scales on young leaves, whereas *D. lanata*, which superficially resemble *D. dunnii*, has stellate scales on leaves in all growth stages (Brummitt, & Utteridge, 2003). The adaxial and abaxial surfaces are glabrescent, and veins are prominent only on the abaxial surface (Flora of China, n.d.). The petiole is 10 to 15 mm long and is the longest of the genus (Flora of China, n.d.).

Flowers that are strictly male occur lower on the inflorescence (Flora of China, n.d.). The male flowers are sessile, with 4-5 stamens per flower, and lack ovaries (Flora of China, n.d.). The filaments are 4-9 mm long, and the anthers are small, just

1.7-2 mm in length (Flora of China, n.d.). The bisexual flowers are borne on a pedicel. Each bisexual flower has 4-11 stamens, a villous ovary, and glabrous styles that are 4-5 mm long (Flora of China, n.d.). Flowers are subtended by oblong bracts (Flora of China, n.d.). The flowering period is from April to June (Flora of China, n.d.). The fruit of *D. dunnii* is smaller than that of *D. lanata* (Brummitt, & Utteridge, 2003). *D. lanata* has capsules that are up to 7.5 mm long, and *D. dunnii* can be up to 13 mm (Brummitt, & Utteridge, 2003; Flora of China, n.d.). The capsules of *D. dunnii* occur singly or up to four per infructescence (Flora of China, n.d.). Each capsule is gray-brown in color, with a subacute apex, and dense sessile scales (Flora of China, n.d.). The type specimen housed at the Kew Herbarium notes *D. dunnii* as having “3-valved fruit”, from the digitized specimen observed this appeared to be true (“Chinese Collector” K000704879, 1907). Each valve holds one, 4-5 mm long seed, and the fruiting period is from June to September (Flora of China, n.d.).

*D. dunnii* occurs in evergreen forests at elevations of 800 to 1,500 m (Flora of China, n.d.). Its range extends seven provinces in China; Fujian, Guangdong, Guangxi, Guizhou, Hunan, Jiangxi, and Yunnan (Flora of China, n.d.). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.5.2 *Distyliopsis lanata* N.A. Brummitt & Utteridge**

Original Publication: Kew Bull. 58: 728 2003

*D. lanata* is a recently described species endemic to Papua New Guinea (Brummitt, & Utteridge, 2003). It is an evergreen tree that grows to 24 m (Brummitt, & Utteridge, 2003). Notes from an isotype describe *in situ* plants as “trees (that) reach well over 100’ in height, 24+” in dia. (meter)” (Streimann, & Kairo 00252372, 1970). Young branches are circular in cross-section and red-brown in color (Brummitt, &

Utteridge, 2003). The bark was also described in the notes of the aforementioned isotype. The notes state that the bark is “gray with some pustules, middle bark reddish, inner bark light red” (Harvard University Herbarium & Libraries, 1970).

The leaves are elliptic, 5-8.8 cm long, and 2-5 cm wide (Brummitt, & Utteridge, 2003). The margin is entire, base acute to rounded, and the apex is acute (Brummitt, & Utteridge, 2003). There are 5-7 veins on each side of the midrib (Brummitt, & Utteridge, 2003). The midrib is covered on both surfaces with a persistent indumentum (Brummitt, & Utteridge, 2003). The adaxial surface is described in the isotype notes as “dull dark green above, covered by brownish down” (Streimann, & Kairo 00252372, 1970). The midrib and secondary veins are impressed, and abaxially they are prominent (Brummitt, & Utteridge, 2003). Brummitt, & Utteridge (2003) describe the abaxial surface as drying a rusty-brown with persistent pubescence that can become reduced as the leaf matures. The isotype notes state that the abaxial surface is “green below, covered by brownish down” (Harvard University Herbarium & Libraries, 1970). The petiole is covered in dense, woolly pubescence and is 6-10 mm long (Brummitt, & Utteridge, 2003).

Flowers are either male or bisexual, with the bisexual flowers having all parts the same as the male but with a floral cup, ovary, and styles (Brummitt, & Utteridge, 2003). The ovary is surrounded by the floral cup, the ovary being just 0.4 mm long, and the floral cup up to 2.5 mm long (Brummitt, & Utteridge, 2003). The styles are 6.5-8 mm in length (Brummitt, & Utteridge, 2003). The male flowers have 4-7 stamens, with filaments that are 2.5-4 mm long, and anthers that are 2 mm in length (Brummitt, & Utteridge, 2003). The inflorescence is a 2-6 flowered panicle held in the

axils (Brummitt, & Utteridge, 2003). Bracts are stipulate, lanceolate, and 2-3 mm long (Brummitt, & Utteridge, 2003).

The fruit is a densely pubescent capsule that is loculicidal (Brummitt, & Utteridge, 2003). The capsule is globose, 10-13 mm long, and 8.5-10 mm wide (Brummitt, & Utteridge, 2003). The observed isotype clearly shows the dense pubescence on both the capsules and the pedicels, and the notes state that the “fruit is dark grey to brownish, covered by brown hairs” (Streimann, & Kairo 00252372, 1970).

*D. lanata* has a restricted range in the Yama region of the Wau Subdistrict in the Morobe Division of Papua New Guinea (Brummitt, & Utteridge, 2003). It is known from just two localities, and despite these localities being close to a botanic research station, it has been over 30 years since the last known collection of *D. dunnii* (Brummitt, & Utteridge, 2003). Brummitt, & Utteridge (2003) state that *D. dunnii* is found on “*Nothofagus*-dominated ridge(s)” and this exact note appears on the observed isotype with the additional details that the specimen was “collected at 5,000 feet” (Harvard University Herbarium & Libraries, 1970). Although, this species is not listed by the IUCN Red List, Brummitt, & Utteridge (2003) believe *D. dunnii* should be listed as “Endangered B2ab(iii)” and hope that by publishing this species name, conservation efforts can be implemented. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.5.3 *Distyliopsis laurifolia* (J.H. Hemsl.) Endress**

Original Publication: Bot. Jahrb. Syst. 90: 30 1970

The *Flora of China* lists the local common name of *D. laurifolia* as “樟叶假蚊母树” or “zhang ye jia wen mu shu” (n.d.). The Plant List 1.1 sites *Distylium*



*velutinum* Hu and *Sycopsis luarifolia* Hemsl. as synonyms (n.d.). *D. laurifolia* is an evergreen shrub that grows to 3 m (Flora of China, n.d.). Young stems are covered in stellate scales and stellate pubescence, and become glabrescent and lenticellate as they mature (Flora of China, n.d.). The leaves are ovate or narrowly ovate, 5-12 cm long, and 2-4 cm wide (Flora of China, n.d.). The margin is entire or apically sparsely toothed, the base is cuneate or obtuse, and the apex is acute or acuminate (Flora of China, n.d.). *D. laurifolia* is the only species in the genus with three prominent basal veins (Flora of China, n.d.). There are 5-6 veins on each side of the midrib (Flora of China, n.d.). The adaxial surface is shiny, and abaxially the leaves have persistent stellate pubescence, or are glaucous with yellow hairs (Flora of China, n.d.). Petioles are 8-10 mm and are with a dense, stellate, pubescence (Flora of China, n.d.).

Flowers are either male or bisexual and occur in inflorescences up to 2 cm long (Flora of China, n.d.). Male flowers are sessile, while bisexual flowers are pedicellate (Flora of China, n.d.). Both types of flowers have a floral cup that is slightly smaller in the bisexual flowers (Flora of China, n.d.). Subglabrous bracteoles are present in both the male and bisexual flowers and are inserted on the floral cup in the male flowers (Flora of China, n.d.). Stamens are grouped 8-12 in the bisexual flowers, and just 1-7 in the male flowers (Flora of China, n.d.). The bisexual flowers have filaments up to 2 mm long, and in the male flowers, filaments are up to 3 mm with ellipsoid anthers that are 0.8-1 mm long (Flora of China, n.d.). The flowering period is from April to June (Flora of China, n.d.). The fruit is a 10-12 mm capsule covered in dense, yellow-brown pubescence (Flora of China, n.d.). The floral cup is persistent, and approximately equal to the capsule length (Flora of China, n.d.). Seeds are 6-7 mm long, and the fruiting period is from June to September (Flora of China, n.d.).

*D. laurifolia* is found in subtropical evergreen forests at elevations of 1,300-1,500 m in the Guizhou and Yunnan Provinces in China (Flora of China, n.d.). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.5.4 *Distyliopsis salicifolia* (H.L. Li & E. Walker) Endress**

Original Publication: Bot. Jarhb. Syst. 90: 30 1970

The Flora of China lists the local common name of *D. salicifolia* as “柳叶假蚊母树” or “liu ye jia wen mu shu” (n.d.). *D. salicifolia* was previously described as *Sycopsis salicifolia* by H. L. Liu ex E. Walker, but was moved to the genus *Distyliopsis* when Peter Endress published it in 1970 (The Plant List 1.1, n.d.). It is an evergreen shrub that grows to 3 m, and notes on the type specimen confirm this adding that the habit is erect, and the diameter was 6 cm (Flora of China, n.d.; Lau 00043476, 1936).

The leaf arrangement is alternate, but not distichous, and somewhat spirally arranged (Flora of China, n.d.). The leaves are narrowly lanceolate, 6-9 cm long, and 1-1.5 cm wide (Flora of China, n.d.). There are 5-7 veins on each side of the midrib, and these are conspicuous abaxially (Flora of China, n.d.). The *Flora of China* describes the leaf as glabrescent on both surfaces (n.d.). The notes from the type specimen state it is “green above”, and it was observed that the dried specimen is significantly darker on the abaxial surface (Lau 00043476, 1936). The petiole is extremely short, being just 3-4 mm (Flora of China, n.d.).

Notes on the type specimen state that the flower of *D. salicifolia* is orange in color, but, as the genus is apetalous and lacking sepals, it is unclear what parts of the flower give it this color (Lau 00043476, 1936). The full inflorescent is 1-2 cm long,

with ovate pubescent bracts that are 2-4 mm long (Flora of China, n.d.). The floral cup is 2-3 mm long (Flora of China, n.d.). Stamens are groups 6-8, and up to 15 per flower (Flora of China, n.d.). The filaments are 2-4 mm long, and the anthers are ellipsoid and 1.8-2 mm long (Flora of China, n.d.). The flowering period is April to May (Flora of China, n.d.). The fruit is a 7-8 mm capsule, borne singly or paired on the 1.5-2.5 cm long infructescence (Flora of China, n.d.). The styles and floral cup are persistent, and the styles are very short with an acuminate apex (Flora of China, n.d.). The fruiting period is June to August (Flora of China, n.d.).

*D. salicifolia* is found in thickets and montane forest at elevations of 900-1,200 m in the Hainan Province of China (Lau 00043476, 1936; Flora of China, n.d.). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.5.5 *Distyliopsis tutcheri* (J.H. Hemsl.) Endress**

Original Publication: Bot. Jarhb. Syst. 90: 30 1970

The *Flora of China* lists the local common name of *D. tutcheri* as “钝叶假蚊母树” or “dun ye jia wen mu shu” (n.d.). Synonyms to *D. tutcheri* include *Sycopsis oblanceolata* H.T. Chang, and *Sycopsis tutcheri* Hemsl. (The Plant List 1.1, n.d.). Surprisingly, *D. tutcheri* is available from a commercial source in the United Kingdom, Junker’s Nursery (Junker’s Nursery, 2018). Their stock list for the 2018-2019 season includes only this species of *Distyliopsis*, but they do offer other members of the Hamamelidaceae (Junker’s Nursery, 2018).

*D. tutcheri* is an evergreen shrub or small tree that grows to 12 m (Flora of China, n.d.). Young stems are covered with sessile peltate scales, and become glabrescent when mature (Flora of China, n.d.). The leaves are elliptic to obovate, 3-6

cm long, and 2-4 cm wide (Flora of China, n.d.). The margin is entire, the base is broadly cuneate, and the apex obtuse or sub-rounded (Flora of China, n.d.). There are 5 veins on each side of the midrib, and these are impressed on the adaxial surface (Flora of China, n.d.). The adaxial and abaxial surfaces are glabrescent (Flora of China, n.d.). The petioles have persistent lepidote pubescence, and are 3-5 mm long (Flora of China, n.d.).

The flowers were not observed, but the capsule was described in the *Flora of China*. The capsules occur singly or in groups up to five per infructescence (Flora of China, n.d.). Each capsule is 10-13 mm long, covered in yellow-brown villous hairs, and held on a 3-6 mm long pedicel (Flora of China, n.d.). The floral cup is 4-5 mm long and persistent (Flora of China, n.d.). The styles are very short and also persistent (Flora of China, n.d.). Seeds are 4-5 mm long (Flora of China, n.d.). The flowering period is believed to be April to June, and the fruiting period is June to September (Flora of China, n.d.).

*D. tutcheri* is found in subtropical evergreen forests at 800-1,000 m elevations (Flora of China, n.d.). It is native to three provinces in China; Fujian, Guangdong, and Hainan (Flora of China, n.d.). The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections. A few institutions in both BGCI data sets reported the synonym *Sycopsis tutcheri* in their collection statistics, *S. tutcheri* is included in the summary report below.

[Table 20 *Distyliopsis tutcheri*: BGCI Institution Report and BGCI Collections Survey

<i>Distyliopsis tutcheri</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	7	3

Countries	5	2
Accessions	N/A	3
Wild Provenance	N/A	0
Plants	N/A	3

### 2.5.6 *Distyliopsis yunnanensis* (H.T.Chang) C.Y. Wu

Original Publication: Fl. Yunnanica 1: 139 1977

The *Flora of China* lists the local common name of *D. yunnanensis* “滇假蚊母树” or “dian jia wen mu shu” (n.d.). *Sycopsis yunnanensis* H.T. Chang is listed as a synonym of *D. yunnanensis* (The Plant List 1.1, n.d.). *D. yunnanensis* was described over 40 years ago, but there is very limited information available on it in the literature. The *Flora of China* describes it as an evergreen shrub or small tree (n.d.). The leaves are oblong, 9-13 cm long, and 3-6 cm wide (Flora of China, n.d.). The margin is entire, the base is broadly cuneate or sub-rounded, and the apex is acute or sub-obtuse (Flora of China, n.d.). There are 6-7 veins on each side of the midrib, and these are conspicuous abaxially (Flora of China, n.d.). Petioles are 6-9 mm long and lepidote (Flora of China, n.d.).

No flower description was found in the literature, but the *Flora of China* does describe the fruit. The infructescence is held in leaf axials or on short shoots held terminally (Flora of China, n.d.). The peduncle is glabrous, and the capsules are stalked or sessile (Flora of China, n.d.). Capsules are held in groups of 3-4 on the infructescence, with each capsule being 8-10 mm long and 6-8 mm wide (Flora of China, n.d.). The capsules are gray-brown in color, with a subacute apex, and are covered in villous hairs (Flora of China, n.d.). The floral cup is 4-6 mm long and persistent (Flora of China, n.d.). The persistent styles are absent in this species of

*Distyliopsis* (Flora of China, n.d.). Fruiting period is July to August (Flora of China, n.d.).

*D. yunnanensis* is found in subtropical evergreen forests at 800-1,000 m elevations (Flora of China, n.d.). It is only found in the Yunnan Province of China (Flora of China, n.d.). The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 21 *Distyliopsis yunnanensis*: BGCI Institution Report and BGCI Collections Survey

<i>Distyliopsis yunnanensis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

## 2.6 *Distylium* Overview

**Nomenclature and Taxonomy:** Commonly called the Isu tree, in Chinese it is “wen mu shu”, or in Japanese it is “isu-no-ki zoku” (Flora of China, n.d.; Ohwi, 1965). The genus *Distylium* was first described in 1835 from specimens in Japan (Ohwi, 1965; Walker, 1944). It is in the subfamily Hamamelidoideae within the tribe Fothergilleae, and part of the subtribe “Fothergillinae” (Li, Bogle, & Klein, 1999). It is closely related to *Sycopsis*, and is strikingly similar in vegetative characteristics (Walker, 1944). This superficial similarity has led to many synonyms between these

genera. *Distylium* can be differentiated from *Sycopsis* using floral characteristics (Walker, 1944). *Sycopsis* is perigynous with an elongated tubular receptacle which fully covers the ovary and ten or fewer stamens per flower (Walker, 1944). Whereas *Distylium* is hypogynous typically with six or fewer stamens per flower (Walker, 1944). A new genus *Saxifragites* Gagnep. was described as a member of the Euphorbaceae in 1950, but was determined to be a type of *Distylium*, and is presently deemed a synonym to *Distylium* (Shaw, 1963). *The Plant List 1.1* lists that *Saxifragites* is unresolved.

Walker notes the extreme variability within the genus, and at the time of his writing he notes a lack of specimens that effectively demonstrate the full extent of the variation (1944). Walker sites this as the reason that numerous species have been described and then relegated to synonym status in such a short time and anticipates more changes in the taxonomy once suitable specimens are made available for study (1944). The number of species within the genus is difficult to count with confidence, Weaver (1976) describes eight species, and a 2017 publication, citing Zhang (1979), states that there are 18 species in the genus, but fail to list these (Yang, Zhang, Kardos, Dirr, & Jin, 2017). For this thesis the species listed as accepted needed to meet the following criteria: each taxon must be listed as accepted by *The Plant List 1.1*, the original name publication details were able to be located in reference materials, and each species was included in at least one reference source with a species description. These criteria allowed for 14 species to be included in this thesis.

In his 1944 publication, Walker states that the genus is in cultivation, predominantly *D. racemosum*. A publication in 1976 from Weaver states that *D. racemosum* is the only species in cultivation and is primarily an ornamental in

California. The Yang et al. paper from 2017 states that the both *D. racemosum* and *D. myricoides* are cultivated in Asian countries, and slowly being introduced into the United States through the University of Georgia. The University of Georgia has undertaken breeding efforts for *Distylium*, and through this program and the efforts of others, some cultivars and hybrids are available commercially (Yang et al., 2017). A cultivar list for this genus is listed at the end of the species descriptions. Additional details for each cultivar are in Appendix A of this thesis.

The genus is native to warm temperate and subtropical forests in Asia (Weaver, 1976). This includes Japan, China, and India (Walker, 1944). In his 1944 work, Walker described two species of *Distylium* being native to Central America, but these species were later moved to the genus *Molinedendron*, and presently no species of *Distylium* naturally occur outside of Asia (Walker, 1944; The Plant List 1.1., n.d.).

**Description:** *Distylium* is an evergreen tree or shrub with young stems that are stellately pubescent or lepidote (Flora of China, n.d.). The buds are naked, although some species have scales or pubescence (Flora of China, n.d.). The leaves are leathery and alternately arranged (Walker, 1944). Walker states that the leaf morphology is highly variable even within an individual species, but the flowering parts between species are so similar, and in some species never observed, that one is forced to use leaves for identification (Walker, 1944). The leaves are ovate to lanceolate and always with pinnate venation (Walker, 1944). The margin is entire or sparsely toothed toward the apex (Walker, 1944). Petioles are consistently short across all species, and stipules are small, lanceolate, and deciduous (Walker, 1944; Ohwi, 1965).

Flowers are apetalous, subtended by two bracteoles, and arranged in a condensed panicle or spike that is held in leaf axils (Flora of China, n.d.; Ohwi, 1965).



Although Walker (1944) describes the sepals as being absent, Ohwi (1965) mentions that the “calyx is free from the ovaries”, and even Walker states that *D. buxifolium*, among other species, have sepals. By definition, having a calyx implies the presence of sepals. No flower samples were observed to confirm the presence or absence of sepals for each species within the genus. The ovary is superior, and lacks a floral cup (Ohwi, 1965; Flora of China, n.d.). Each flower has two styles, with short filaments, and anther that are red and oblong (Ohwi, 1965; Walker, 1944). Flowers are monoecious or andromonecious (Flora of China, n.d.). Walker cautions that it can be difficult to distinguish if the flowers are unisexual or bisexual due to the varying degree of presence and development of reproductive parts of either gender (1944). The Flora of China does provide descriptions for both the male flowers and the bisexual flowers. The Flora of China states that male flowers have 1-8 stamens, but Walker observes there being no more than six stamens per flower in *Distylium* (1944). Male flowers have filaments of unequal length, with ellipsoid anthers, and two-sporangiate dehiscent thecae (Flora of China, n.d.). The bisexual flowers have 5-8 stamens, a superior ovary with one ovule per locule, and each stigma is decurrent (Flora of China, n.d.). The flowering period is in early spring (Walker, 1944). The fruit is a woody, dehiscent capsule that has either two or four valves (Flora of China, n.d.). The capsules are ovoid to globose, stellately tomentose, and arranged either distichously or spirally in the infructescence (Flora of China, n.d.).

Many institutions reported *Distylium* to just the genus level or cultivars only known to the genus. These taxa were all listed as *Distylium* sp. in the summary of the BGCI data sets. Of the 157 plants reported in the BGCI Collections Survey, 107 of these are named cultivars. Summaries to the species level are included under the

corresponding species description. The table below is a summary of the two BGCI data sets for *Distylium* sp. in *ex situ* collections.

Table 22 *Distylium* sp.: BGCI Institution Report and BGCI Collections Survey

<i>Distylium</i> sp.	BGCI Institution Report	BGCI Collections Survey
Institutions	12	11
Countries	3	4
Accessions	N/A	119
Wild Provenance	N/A	1
Plants	N/A	157

### 2.6.1 *Distylium annamicum* (Gagnep.) A. Shaw

Original Publication: Kew Bull. 17:264 1963

*D. annamicum* was listed as accepted by The Plant List 1.1, but the only source of information found on this species was the Thai Forestry Bulletin's *Studies in Thai Flora* (Phengklai, 1985). Attempts were made to locate digitized herbarium specimens, but none were located. *D. annamicum* is an evergreen tree, native to evergreen forests in Vietnam and Thailand (Phengklai, 1985). The first occurrence of this species in Thailand was recorded by Dr. C.F. van Beusekom in 1971 (Phengkai, 1985). Only two *Distylium* species are native to Thailand, *D. annamicum* and *D. indium* (Phengklai, 1985). The leaves are glabrous and lanceolate with an entire margin, cuneate base, and a cuspidate apex that is unique for the genus (Phengklai, 1985). The leaves are 4-12 cm long and only 1-2 cm wide (Phengklai, 1985). Like all members of the genus, *D. annamicum* is apetalous with flowers assembled in a spiked

inflorescence (Phengklai, 1985). Sepals are either lacking or caducous (Phengklai, 1985). Flowering and fruiting period is described as December to March (Phengklai, 1985). The fruit is a woody, ellipsoid capsule that is 1 cm long and only 0.5 cm wide (Phengklai, 1985). When young, these capsules are hairy (Phengklai, 1985). The peduncle is 0.5 cm long (Phengklai, 1985). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.6.2 *Distylium buxifolium* (Hance) Merr.**

Original Publication: Sunyatsenia 3: 251 1936

The Flora of China lists the local common name as “小叶蚊母树” or “xiao ye wen mu shu”. Due to the variation in *Distylium* morphology, *D. buxifolium* has quite a few synonyms in the literature including; *D. buxifolium* var. *Rotundum* H.T. Chang, *D. lipoense* Y.K. Li & X.M. Wang, and *D. strictum* Hemsl. (The Plant List 1.1., n.d.). *D. chinense* was listed by Walker as a synonym in 1944, but most modern sources recognize *D. chinense* as a unique and accepted species.

*D. buxifolium* is an evergreen shrub growing to 2 m (Walker, 1944). The young stems are grayish brown and stellate-puberulent maturing to be glabrescent (Walker, 1944). Walker (1944) describes plants as “densely branching” and The Flora of China notes that the internodes are quite short, just 1-2.5 cm. The leaves are either alternately, or alternate and spirally arranged (Flora of China, n.d.). The leaves are very variable, but typically are lanceolate to obovate, 2-5 cm long, and 1-1.8 cm wide (Walker, 1944; Flora of China, n.d.). The margin can be entire, or sparsely toothed towards the apex (Walker, 1944). The leaf base is acute or narrowly cuneate, and the apex is acute, obtuse, or mucronate (Walker, 1944; Flora of China, n.d.). Walker (1944) states that the leaves have 4-5 vein pairs, whereas the Flora of China states

there are 3-6 vein pairs. Both sources state that the veins are not conspicuous on either leaf surface (Walker, 1944; Flora of China, n.d.). The leaves are glabrous adaxially and can be either glabrous or puberulent abaxially (Flora of China, n.d.; Walker, 1944). The petiole is just 2 mm long (Walker, 1944).

The flowers of *D. buxifolium* were not observed for the publication of the *Flora of China*. Therefore, the floral descriptions here are based solely on Walker’s 1944 publication. The inflorescence is subglobose to spicate (Walker, 1944). Walker does state that the flowers have sepals, and that these resemble the bracts, both being ovate and 3 mm long, with or without pubescence (1944). Each flower has up to six stamens, filaments of varying length (up to 3 mm), and large red anthers (Walker, 1944). The flowering period is believed to be April to May (Flora of China, n.d.). Capsules are ovoid and 7 mm long (Walker, 1944). Each infructescence is 2 cm long and holds one to eight capsules (Walker, 1944).

*D. buxifolium* is described by Walker as being “the most common species in China” (1944). It is native to river and stream sides at elevations between 1,000 and 1,2000 m in eight provinces in China; Fujian, Guangdong, Guangxi, Guizhou, Hubei, Hunan, Sichuan, and Zhejiang (Flora of China, n.d.). The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections.

[Table 23 *Distylium buxifolium*: BGCi Institution Report and BGCi Collections Survey

<i>Distylium buxifolium</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	2	4
Countries	2	3
Accessions	N/A	4

Wild Provenance	N/A	0
Plants	N/A	4

### 2.6.3 *Distylium chinense* (Fr. ex Hemsl.) Diels

Original Publication: Bot. Jahrb. Syst. 29: 290 1900 (The Plant List 1.1, n.d), and Bot. Jahrb. Syst. 29: 380 1900 (Flora of China, n.d.)

*D. chinense* was once considered a variety of *D. racemosum* (The Plant List 1.1, n.d.). Presently *D. racemocum* var. *chinense* Franch. ex Hemsl. is considered a synonym of the accepted name *D. chinense* (The Plant List 1.1, n.d). It is an attractive plant with interesting flowers and has a sturdy root system that makes it ideal for use in erosion management (Li, Wang, Luan, Yang, Cheng, Dai, Mei, & Huang, 2014; Liu, Cheng, Xiao, Guo, & Wang, 2014). Li et al. describe it being used ornamentally in gardens, greenbelts, and roadsides (2014). *D. chinense* is an evergreen shrub or small tree growing to 1 m (Li et al., 2014; Flora of China, n.d.). Like most *Distylium* older stems are glabrescent, and young branches are thick (Liu et al., 2014; Flora of China, n.d.). The bark on mature plants is light brown (Li et al., 2014).

The leaves are elliptic to oblanceolate, 2-4 cm long, and 1-1.2 cm wide (Liu et al., 2014). The margin is entire with two or three teeth on each apical part of the leaf (Liu et al., 2014). The base is broadly cuneate, the apex is subacute, and the leaf is glabrous on both the adaxial and abaxial surfaces (Liu et al., 2014). The five vein pairs are not conspicuous on either surface (Liu et al., 2014). The petiole is densely lepidote and 1.5-2 mm in length (Liu et al., 2014).

Flower details are limited in the literature. The *Flora of China* states that the inflorescence is 1-1.5 cm long with ovate or floral bracts at the base of each flower (n.d.). These bracts being 1.2-1.5 mm long (Flora of China, n.d.). Stamens are 4-7 mm

long and are in groups of 2-7 per flower (Flora of China, n.d.). The filaments are slender, and the anthers are ovoid, but it was not stated if they are red in color like all other species in the genus (Flora of China, n.d.). Liu et al. state flowering period is in early spring, and the fruiting period is autumn (2014). Whereas the Flora of China sites the flowering period as being April to June, and the fruiting period June to August (n.d.). The capsules of *D. chinense* are four-valved, and 0.7-0.8 cm long, and each valve holds one seed that is 3-4 mm in length (Flora of China, n.d.).

*D. chinense* is native to Hubei and Sichuan provinces in China and occurs in wetlands or along rivers at elevations between 1,000 and 1,300 m (Flora of China, n.d.). Li et al. note its occurrence in the Three Gorges Reservoir Area along the Yangtze River, and observed that *D. chinense* is very flood-tolerant (2014). Although not listed on the IUCN Red List or the China Red List as being of conservation concern, Li et al. stated that presence of the Three Gorges Reservoir and overharvesting is negatively impacting wild populations (2014). The Three Gorges Dam and Reservoir creates flooding situations up to 175 m deep (Li et al., 2014). Despite *D. chinense* being flood-tolerant, this situation is causing a decline in wild populations (Li et al., 2014). Overharvesting of plants for anthropogenic uses is at a rate that exceeds replacement (Li et al., 2014). Anthropogenic uses of *D. chinense* include; paper pulp, furniture, fuel, traditional medicine, analgesics, and antirheumatic medicines (Li et al., 2014). In addition, propagation can be difficult due to low germination rates and the slow rooting of cuttings (Li et al., 2014). Li et al. believe current propagation methods are too slow for the present commercial needs of the plant. The BGCI Collections Survey only reported one garden with *D. chinense* in its living collection. This garden was the Xishuangbanna Tropical Botanical Garden in

China, and only one accession was reported. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 24 *Distylium chinense*: BGCI Institution Report and BGCI Collections Survey

<i>Distylium chinense</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	1
Countries	1	1
Accessions	N/A	1
Wild Provenance	N/A	0
Plants	N/A	1

#### 2.6.4 *Distylium chungii* (Metcalf) W.C. Cheng

Original Publication: Contr. Biol. Lab. Chin. Assoc. Advancem. Sci., Sect. Bot. 8: 140 1932.

The Flora of China states that the local common name is “闽粤蚊母树” or “min yue wen mu shu” (n.d.). The Plant List 1.1 recognizes *Sycopsis chungii* F.P. Metcalfe as a synonym to the accepted name *D. chungii* (Metcalf) W.C. Cheng. *D. chungii* is an evergreen tree that grows to 20 m (Walker, 1944). Young branches are densely pubescent, and mature to be glabrous or lenticellate and gray-brown colored (Flora of China, n.d.). Buds are naked and are stellately tomentose (Walker, 1944; Flora of China, n.d.). The leaves are oblong to ovate, 5-10 cm long, and 2.5-4 cm wide (Walker, 1944; Flora of China, n.d.). The margin is entire or sparsely toothed towards the apex (Walker, 1944). Walker (1944) describes the leaf base as obtuse to rounded, whereas the *Flora of China* describes the base as broadly cuneate. The apex is sub-

rounded to obtuse, and has either an acuminate or apiculate tip (Walker, 1944). Five to six vein pairs occur on each leaf, and veins are prominent on both sides of the leaf (Walker, 1944). The adaxial surface is shiny with an impressed midrib and veins, the leaf is glabrous except on the midrib (Walker, 1944). The abaxial surface has sparse stellate pubescence, this pubescence is prominent on the raised midrib (Flora of China, n.d.; Walker, 1944). The petiole has dense stellate pubescence and is 1 cm long (Walker, 1944).

The flower of *D. chungii* was not observed by either Walker (1944) or the *Flora of China* (n.d.). Walker does note that Hsian Hsuan Chung described the flower as red and given the characteristics of the other species within this genus, this most likely is attributed to the anther color (1944). Walker did observe a vouchered specimen with an infructescence. From this he observed that the infructescence is 2 cm long and densely stellate-lepidote or puberulent (Walker, 1944). The capsules are ovoid, 1.2 cm long, and are also densely stellate-lepidote or puberulent (Walker, 1944). The *Flora of China* states that there are 2-3 capsules per infructescence and each capsule has two, two-lobed valves that each hold one 6-7 mm long seed (n.d.). Fruiting period is August (*Flora of China*, n.d.). *D. chungii* is native to the Fujian, and Guangdong provinces of China, and is found at elevations between 1,000 and 1,2000 m (*Flora of China*, n.d.). *D. chungii* is not listed as being of local or global conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.5 *Distylium dunnianum* H. Lévl.**

Original Publication: *Repert. Spec. Nov. Regni Veg.* 11:67 1912



The Flora of China states that the common name for *D. dunnianum* is “窄叶蚊母树” or “zhai ye wen mu shu” (n.d.). Synonyms of *D. dunnianum* include *D. lanceolatum* Chun ex. W.C. Cheng, and *Myrica seguinii* H. Lév. (The Plant List 1.1, n.d.). *D. dunnianum* is an evergreen shrub or small tree that grows to 6 m (Flora of China, n.d.). Stems are angular and stellately tomentose when young, and mature to be glabrescent and gray-brown (Flora of China, n.d.). The leaves are lanceolate, 6-10 cm long, and 1.2-2.2 cm wide (Flora of China, n.d.). The margins are entire, and the presence of teeth towards the apex was not included in the species description (Flora of China, n.d.). The leaf base is rounded or broadly cuneate, and the apex is acute (Flora of China, n.d.). The leaf is glabrous on both the abaxial and adaxial surfaces. Abaxially the 6-9 lateral veins are somewhat prominent (Flora of China, n.d.). The petiole is stellately tomentose and 5-8 mm long (Flora of China, n.d.).

The flowers were not observed in the *Flora of China*, and this species was not included in Walker’s 1944 publication. The infructescence is axillary and 3-5 cm long (Flora of China, n.d.). The dehiscent capsules are 1-1.2 cm in diameter and have four valves. Each valve holds one seed that is 4-5 mm long (Flora of China, n.d.). The fruiting period is in August (Flora of China, n.d.). *D. dunnianum* is native to four provinces in southern China; Guangdong, Guangxi, Guizhou, and Yunnan (Flora of China, n.d.). It occurs on slopes in forested habitats at elevations between 1,200 and 1,400 m (Flora of China, n.d.). This species was not listed by the IUCN Red List and is not of local conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.6 *Distylium elaeagnoides* H.T. Chang**

Original Publication: Acta. Sci. Nat. Univ. Sunyatseni 1959(2): 37 1959

The *Flora of China* lists the local common name of *D. elaeagnoides* as “鳞毛蚊母树” or “lin mao wen mu shu” (n.d.). *D. elaeagnoides* is an evergreen shrub or small tree growing to 6 m (Flora of China, n.d.). The young stems are stellately lepidote, and mature to become glabrescent or lenticellate and gray-brown in color (Flora of China, n.d.). The buds are small, ovate, naked, and stellately lepidote (Flora of China, n.d.).

The leaves are obovate or oblong, 5-10 cm long, and 2.5-4.5 cm wide (Flora of China, n.d.). The margin is entire, and like *D. dunnianum*, the presence of sparse teeth towards the apex was not included in the description (Flora of China, n.d.). The base is cuneate, and the apex is obtuse or rounded (Flora of China, n.d.). *D. elaeagnoides* only has 4-5 vein pairs, which helps distinguish it from *D. dunnianum* which has 6-9 vein pairs (Flora of China, n.d.). The adaxial surface is glabrescent, and the abaxial surface is silver or gray in color and densely lepidote (Flora of China, n.d.). The silver leaf back is another distinguishing characteristic of *D. elaeagnoides* that helps separate it from *D. dunnianum* (Flora of China, n.d.). The petiole is stellately lepidote and 8-12 mm long (Flora of China, n.d.). *D. elaeagnoides* has one of the longest petioles in the genus (Flora of China, n.d.).

No observations of the flowers were included in the *Flora of China*, and this species was not included in Walker's 1944 publication. The fruit is a narrow woody capsule that is ovoid to globose, 1.4-1.6 cm long, and 0.6-0.8 cm wide (Flora of China, n.d.). The capsule is gray and densely lepidote (Flora of China, n.d.). Each capsule dehisces by two, two-lobed valves (Flora of China, n.d.). Each valve holds one 2-3 mm long seed, and the fruiting period is August (Flora of China, n.d.). *D. elaeagnoides* is found in montane evergreen forests as elevations between 800 and

1,000 m (Flora of China, n.d.). It is native to three provinces in China; Guangdong, Guangxi, and Hunan (Flora of China, n.d.). *D. elaeagnoides* is not listed locally or by the IUCN Red List as being of conservation concern. The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections.

[Table 25 *Distylium elaeagnoides*: BGCi Institution Report and BGCi Collections Survey

<i>Distylium elaeagnoides</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	1	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

### 2.6.7 *Distylium gracile* Nakai

Original Publication: J. Arnold Arbor. 5: 77 1924

The Flora of China lists the local common name of *D. gracile* as “台湾蚊母树” or “ai wan wen mu shu” (n.d.). *D. gracile* is a small, evergreen tree that grows to 10 m (Lu, & Pan, 1998; Walker, 1944). Young branches are slender with stellate pubescence and gray-brown in color (Walker, 1944). Mature branches become glabrescent (Walker, 1944). The buds are naked and are stellately tomentose (Flora of China, n.d.). The leaves are broadly elliptic-ovate to obovate, 2-5 cm long, and 0.7-2 cm wide (Walker, 1944). The margin is entire and seldomly with 1-2 teeth on each side toward the apex (Walker, 1944). The base is obtuse, acute, or even broadly

cuneate (Walker, 1944; Flora of China, n.d.). The apex is obtuse to rounded, which Walker states is a distinguishing feature of *D. gracile* (Walker, 1944). There are only 3-4 vein pairs per leaf, and these are only moderately conspicuous (Walker, 1944). Both the adaxial and abaxial surfaces are glabrous (Flora of China, n.d.). The petiole is very short, just 2-4 mm, and has stellate pubescence (Walker, 1944).

Both Walker and the *Flora of China* did not have floral observations. The infructescence is a 1.5-3 cm long raceme (Walker, 1944). The fruit is a globose to ovoid capsule that is 1 cm long (Walker, 1944). The capsules are light brown and stellately pubescent (Walker, 1944). The fruiting period is July to August (Flora of China, n.d.). *D. gracile* is native to limestone forests of Taiwan, and Zhejiang China between 1,000 and 1,200 m elevations (Lu, & Pan, 1998). This is the only species of *Distylium* listed by the IUCN Red List, and is listed as “Endangered Aid, C2a” (Lu, & Pan, 1998). Population fragmentation in combination with mining and quarrying activities are negatively impacting this species (Lu, & Pan, 1998). In addition, mature individuals are declining, and individual replacement is not being maintained (Lu, & Pan, 1998). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.8 *Distylium indicum* Benth. ex C.B. Clarke**

Original Publication: Fl. Brit. India 2: 427 1878

*D. indicum* is a small, evergreen tree (Walker, 1944). Young branches have distinct ferruginous pubescence, and mature to be glabrescent (Walker, 1944). The leaves are obovate to elliptic, 6-10 cm long, and 3-6 cm wide (Walker, 1944; Phengklai, 1985). The margin is entire, base cuneate, and the apex is rounded or acuminate (Walker, 1944). *D. indicum* has six veins on each side of the midrib

(Walker, 1944). The leaf can be either glabrous or pubescent on each surface, but is green adaxially and is notably brown on the abaxial surface (Walker, 1944). Abaxially the veins are raised (Walker, 1944). The petioles are margined, and 1 cm long, the petiole margin is unique to this species of *Distylium* (Walker, 1944).

Flowers are grouped into spikes or racemes that are up to 6 cm long (Walker, 1944). Walker states that *D. indicum* has both bracts and sepals, but that they are caducous (1944). This could account for Walker's generalization that all *Distylium* lack sepals (1944). Mature fruits were not observed by Walker, but the immature fruits were described as 1.3 cm long with dense stellate pubescence (Walker, 1944). The flowering and fruiting period extends from January to April (Phengklai, 1985).

*D. indicum* is found in evergreen forests near streams at elevations between 600 and 1,300 m (Phengklai, 1985). It is native to India and Thailand (Walker, 1944; Phengklai, 1985). The type being described from India in 1878, and the populations in Thailand not being discovered until 1974 by Dr. R. Geesink (Phengklai, 1985). Walker described the prevalence of *D. indicum* in India as "apparently rare", but with the expansion of range into Thailand since this observation, *D. indicum* is likely more common than originally assumed (Walker, 1944). *D. indicum* is not listed by the IUCN Red List or locally as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.9 *Distylium lepidotum* Nakai**

Original Publication: Bot. Mag. (Tokyo) 32: 220 1918

*D. lepidotum* was first collected in 1853 by American botanist Charles Wright (Walker, 1944). Wright's vouchered specimens were distributed to the Gray Herbarium, U.S. National Herbarium, and the Kew Herbarium. It was not until 1918

that *D. lepidotum* was described, but even at the time of his writing in 1944, Walker noted that each of the Wright specimens still had separate unpublished “herbarium names”, which were not listed in Walker’s publication as he did not consider them accepted names (Walker, 1944).

*D. lepidotum* is an evergreen shrub or small tree growing up to 3 m in shrub form, or up to 10 m in tree form (Walker, 1944). The young stems are gray and densely lepidote, turning glabrescent as they mature (Walker, 1944). The leaves are broadly elliptic-ovate, 2-4 cm long, and 1.5-2.5 cm wide (Walker, 1944). The margins are entire and rarely toothed (Walker, 1944). The base is obtuse, and the apex rounded or even broadly obtuse (Walker, 1944). There are four inconspicuous vein pairs on each side of the prominent mid-rib (Walker, 1944). Both the adaxial and abaxial surfaces are green and glabrous, the mid-rib being more prominent abaxially (Walker, 1944). The petiole is 5 mm long and glabrous or lepidote (Walker, 1944).

Flowers are apetalous, and this is another species in the genus that Walker describes has both bracts and sepals present, thus negating part of his genus description (Walker, 1944). Bracts are ovate and lepidote, sepals are lanceolate and either glabrous or lepidote (Walker, 1944). There are up to four stamens per flower, the filaments are of varying lengths, and the anthers are large and apiculate (Walker, 1944). The fruit is a woody capsule that is held singularly or in sparse groups. The young capsule is densely lepidote, and matures to be 1.5 cm long (Walker, 1944). *D. lepidotum* is a dominant tree in part of its range, this is referred to as the “*Distylium-Pouteria* dry scrub” community by Sugai, & Setsuko (2016). It is endemic to the Ogasawara Islands in the Northwest Pacific Ocean (Sugai, & Setsuko, 2016). Although the Ogasawara islands are technically part of Japan, the geologic records

show that the islands were never connected (Segai, & Setsuko, 2016). Therefore, the Ogasawara islands are home to many endemic species, including a locust, *Boinoxya anijimensis*, that uses *D. lepidotum* as its only source of food (Sugia, & Setsuko, 2016).

Despite its limited range and endemic status, *D. lepidotum* is not listed by the IUCN Red List or locally as being of conservation concern. Two accessions of *D. lepidotum* were reported in the BGCI Collections Survey from two institutions. These institutions are both located in Hawaii, and both accessions are of wild origin from the same collection by Dr. Mikio Ono in 1976 from the Ogasawara Islands. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 26 *Distylium lepidotum*: BGCI Institution Report and BGCI Collections Survey

<i>Distylium lepidotum</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	3	2
Countries	2	1
Accessions	N/A	2
Wild Provenance	N/A	2
Plants	N/A	2

#### 2.6.10 *Distylium macrophyllum* H.T. Chang

Original Publication: Acta. Sci. Nat. Univ. Sunyatseni 1960(1): 39 1960

The *Flora of China* lists the local common name of *D. macrophyllum* as “大叶蚊母树” or “da ye wen mu shu” (n.d.). *D. macrophyllum* is an evergreen shrub or small tree that grows to 5 m (Flora of China, n.d.). Young stems are stellately lepidote

and are angular (Flora of China, n.d.). Buds are naked, narrowly ovoid, and 6 mm long (Flora of China, n.d.). The buds are either stellately pubescent or stellately lepidote (Flora of China, n.d.). The leaves are elliptic or ovate-elliptic, 7-12 cm long, and 3.5-6.5 cm wide (Flora of China, n.d.). The margin is entire or dentate towards the apex, each tooth being abrupt and sharp (Flora of China, n.d.). The leaf base is rounded or obtuse, and the apex acute or subobtuse (Flora of China, n.d.). There are 5-6 vein pairs (Flora of China, n.d.). Both the adaxial and abaxial surfaces are glabrous, but the veins are more prominent abaxially (Flora of China, n.d.).

The *Flora of China* did not provide a flower description, and no additional sources were located that provided one. The infructescence is 5-7 cm, the peduncle stellately lepidote, and the pedicels glabrous and 2-5 mm long (Flora of China, n.d.). The fruit is a woody capsule, 1.2-1.5 cm long, and 1-1.2 cm wide (Flora of China, n.d.). Seeds are 5-7 mm long, and the fruiting period is in August (Flora of China, n.d.). *D. macrophyllum* is native to two provinces in China; Guangdong and Guangxi. It is found at elevations between 1,000 and 1,200 m (Flora of China, n.d.). *D. macrophyllum* is not listed by the IUCN Red List or locally as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.11 *Distylium myricoides* Hemsl.**

Original Publication: Hooker's Icon. Pl. 29: t. 2835 1909

*D. myricoides* var. *nitidum* H.T. Chang is a synonym for the accepted name *D. myricoides* (The Plant List 1.1, n.d.). *D. myricoides* is found in cultivation in Asian countries and starting to be found in cultivation in Europe and the United States (Yang, Zhang, Kardos, Dirr, & Jin, 2017). Although *D. racemosum* is the more



common species in cultivation, *D. myricoides* cultivars do exist and it is also part of the parentage for *Distylium* hybrids in the trade (Yang, Zhang, Kardos, Dirr, & Jin, 2017). A handful of online suppliers of *D. myricoides* in the United States and the United Kingdoms were located via an internet search. In cultivation, *D. myricoides* is a small shrub growing to just 3 m, *in situ* it is a tree that grows to 20 m (Walker 1944). Young branches are gray-brown and somewhat lepidote, and when mature retaining the coloration, but becoming glabrescent and lenticellate (Walker, 1944; Flora of China, n.d.). Buds are naked and are stellately pubescent or stellately lepidote (Walker, 1944).

The leaves are elliptic-ovate or obovate, 5-10 cm long, and 2-4 cm wide (Walker, 1944). Walker states that the leaves are similar to *D. buxifolium*, but that *D. myricoides* has a larger lamina (1944). The margin is entire or sparsely toothed towards the apex (Walker, 1944). Teeth are described as “callose serrate” (Walker, 1944). The base is acute or cuneate, and the apex is acute, rarely acuminate (Walker, 1944; Flora of China, n.d.). Walker (1944) states that there are 5 vein pairs, whereas the *Flora of China* states there are 6 (n.d.). The veins are raised on the pale abaxial surface (Walker, 1944). Adaxially the leaves are shiny and glabrous (Walker, 1944). The petioles are lepidote and 5-10 mm long (Walker, 1944).

The inflorescence is a short lepidote spike or raceme that is 1-3 cm long (Walker, 1944; Flora of China, n.d.). Again, Walker states that sepals are present, but states that both the sepals and bracts are variable (1944). The bracts are lanceolate, caducous, and 2-3 mm long (Flora of China, n.d.). The ovary is stellately pubescent with styles that are 6-8 mm long (Flora of China, n.d.). Walker describes the stamen number as “few”, and the anthers are large and apiculate (Walker, 1944). The red

anthers are 2-3 mm long and held on filaments that are less than 2 mm in length (Flora of China, n.d.). The flowering period is April to June (Flora of China, n.d.). The infructescence is 2 cm long and is held on a lepidote peduncle (Walker, 1944; Flora of China, n.d.). The capsules are held singly or in small groups, each being 1 cm long (Walker, 1944). Capsules are elliptic or ovoid, and densely lepidote or puberulent (Walker, 1944). The *Flora of China* describes the capsules as a yellow-brown in color, and Walker states they are gray-green, but “not ferruginous” (1944). Capsules dehisce by four valves, with seeds that are 6-7 mm long, and the fruiting period is June to August (Flora of China, n.d.).

*D. myricoides* is common in Karst forests, open woods or thickets, and montane evergreen forests at elevations between 500 and 800 m (Zhang, Hu, Zhu, Luo, & Ni, 2010; Walker, 1944; Flora of China, n.d.). It is native to subtropical China in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hunan, Jiangxi, Sichuan, Yunnan, and Zhejiang provinces in China (Flora of China, n.d.). *In situ*, *D. myricoides* can tolerate slight shade (Zhang et al., 2010). *D. myricoides* is not listed by the IUCN Red List or locally as being of conservation concern. The BGCI Collections Survey reported 39 accessions of *D. myricoides* from 16 institutions. These institutions were from North America, Europe, Australia, and China. Only three accessions were of wild origin, and these were all from the same provenance, and held in the same institution in the United States. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 27 *Distylium myricoides*: BGCI Institution Report and BGCI Collections Survey

<i>Distylium myricoides</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	42	16
Countries	10	10
Accessions	N/A	39
Wild Provenance	N/A	3
Plants	N/A	44

#### 2.6.12 *Distylium pingpienense* (Hu) E. Walker

Original Publication: Bull. Fan Mem. Inst. Biol. Bot. 10: 149 1940

The original publication of the name *Sycopsis pingpiensis* Hu is listed by Walker (1944) as the original publication. Walker's publication in 1944 was the first to publish this as a synonym to *Distylium pingpiense* (Hu) E. Walker. Another synonym of *D. pingpienense* is *D. pingpienense* var. *serratum* E.H. Walker (The Plant List 1.1, n.d.). There is an accepted variety *D. pingpienense* var. *cuspidatum* (H.T. Chang) Z. Yu Li (The Plant List 1.1, n.d.). This variety was proposed by Walker in 1944 to draw attention to this plant material as it has distinct apiculate serrations and pubescence on the fruit. Walker notes that this variety may be part of the plasticity within the species, but hopes that by naming it, others will study the material more closely and come to a consensus (1944). Presently the *Flora of China* (n.d.) recognizes this material as a valid species, *D. cuspidatum* H.T. Chang, but The Plant List 1.1 (n.d.) agrees with Walker's assessment that it is a variety. Until additional analysis is done on this material it seems logical to leave it as a variety.

*D. pingpienense* is an evergreen shrub or small tree that grows 3-8 m (Flora of China, n.d.). Young stems are slender and are stellately pubescent (Walker, 1944). Mature branches become glabrescent and lenticellate (Flora of China, n.d.). The buds are brown in color, naked, and tomentose (Flora of China, n.d.). Leaves are ovate, elliptic-ovate, or even lanceolate, 7-14 cm long, and 2.5-3.7 cm wide (Walker, 1944; Flora of China, n.d.). The margin is described by Walker (1944) as only entire, but the *Flora of China* (n.d.) states that it can have 1-3 teeth towards the apex. The leaf base is asymmetric, obtuse or rounded, and the apex is acuminate (Walker, 1944). Walker (1944) states that there are 5-8 veins pairs, and the *Flora of China* (n.d.) states that there are 6 vein pairs. Both sources agree that the veins are prominent on the abaxial surface (Flora of China, n.d.; Walker, 1944). The adaxial surface is shiny, and the abaxial surface can be glabrous or have brown stellate pubescence (Walker, 1944; Flora of China, n.d.). The petiole is stellately pubescent and 5-10 mm long (Flora of China, n.d.). what is more powerful than gods, evil than demons, poor have me, rich need me, if you have me you will die = nothing

The flowers were not observed by Walker (1944), but the *Flora of China* does include a description of the male flowers and fruit. The male inflorescence is 1-1.5 cm long, subtended by brown stellately pubescent bracts (Flora of China, n.d.). The bracts are oblong and 6-7 mm long (Flora of China, n.d.). Floral bracts are stellately tomentose and 2-3 mm long (Flora of China, n.d.). Filaments are of varying lengths, 1.5-2.5 mm long, and the anthers are of similar size, 1.5-2 mm long (Flora of China, n.d.). The flowering period is from April to June (Flora of China, n.d.). The infructescence is 3-5 cm long. Capsules are ovoid to globose, 1-1.2 cm long, and held on pubescent pedicels that are 3-4 mm long (Flora of China, n.d.). Each capsule is

covered in brown stellate pubescence, and dehisces by two, two-lobed valves (Flora of China, n.d.). Each lobe holds one seed that is 5-6 mm long, and the fruiting period is from June to August (Flora of China, n.d.). *D. pingpienense* is found in evergreen forests at 800 to 1,000 m elevations (Flora of China, n.d.). It is native to three provinces in China; Guizhou, Hubei, and Yunnan (Flora of China, n.d.). *D. pingpienense* is not listed by the IUCN Red List or locally as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.13 *Distylium racemosum* Siebold. & Zucc.**

Original Publication: Fl. Jap. 1: 179 1841

Walker (1944) cites the above references as the original publication, however, the *Flora of China* (n.d.) notes the original publication as “Fl. Jap. 1: 178. 1835”, six years prior. The consensus indicates that the genus *Distylium* was first described in 1835 from specimens in Japan (Ohwi, 1965; Walker, 1944). *The Plant List 1.1* provides a long list of synonyms to *D. racemosum* including; *D. racemosum* var. *angustifolium* Masam., *D. racemosum* f. *angustifolium* (Masam.) H. Ohba, *D. racemosum* var. *pendulum* Makino, and *D. racemosum* f. *pendulum* (Makino) Okuyama (*The Plant List 1.1*, n.d.). Additionally, the horticultural form *D. racemosum* var. *variegatum* H. Harma can be found in the literature. *D. racemosum* goes by the common names “isu tree” or “wen mu shu” (Dirr, 1998; Flora of China, n.d.). It is the most common species in cultivation and was the most reported species of *Distylium* in the BGCI Collections Survey (Walker, 1944).

*D. racemosum* is an upright, open shrub in cultivation, but a 25 m tree *in situ* (Dirr, 1998; Walker, 1944). Young stems are densely stellate-lepidote and mature to

be glabrescent branches with vertical fissures (Walker, 1944; Dirr, 1998). Walker (1944) describes the buds of all *Distylium* as naked, but Dirr (1998) states that the buds of *D. racemosum* are scaled, gray-brown, and with a “dusty” pubescence. Dirr describes the buds as ovoid, fused together, 5 mm long, and that the floral and vegetative buds are mixed (1998).

*D. racemosum* leaves are evergreen, leathery, and shiny (Koike, 2001; Dirr, 1998). The lamina is elliptic, ovate, or slightly obovate, 5-8 cm long, and 2-4 cm wide (Walker, 1944). The margin is entire, and the apex obtuse, acute, or nearly rounded (Walker, 1944). The base is described by Walker (1944) as acute to obtuse, by the *Flora of China* (n.d.) as cuneate, and by Dirr as “blunt, broadly tapering to almost round at base” (1998). Observations of digitized herbarium specimens shows that all of these descriptions are accurate, which supports Walker’s lamentation of the variability within each species. The midrib is prominent on the abaxial surface, and the 5-6 vein pairs are not conspicuous on either surface (Walker, 1944; *Flora of China*, n.d.). The abaxial surface is glabrescent and pale, but Walker notes that all specimens collected from Hong Kong are brown abaxially, much like *D. indicum* (*Flora of China*, n.d.; Dirr, 1998; Walker, 1944). The petiole can be glabrous or sparsely stellately lepidote and is 5-10 mm long (Walker, 1944; *Flora of China*, n.d.).

The inflorescence is a stellate or lepidote raceme that is 1.8-2 cm long, and held on a glabrous peduncle (Walker, 1944; *Flora of China*, n.d.). The bracts are stellately pubescent or lepidote, ovate to oblong, and 4 mm long (Walker, 1944). Sepals are lanceolate or ovate, 3 mm long, and arranged in a five-part calyx (Walker, 1944; Dirr, 1998). The floral bracts are lanceolate and 2-3 mm long (*Flora of China*, n.d.). The ovary is stellately tomentose, and the two styles are 6-7 mm long (*Flora of*

China, n.d.). Each flower can have up to six anthers (Walker, 1944). Each anther is red, apiculate, and 4 mm long (Walker, 1944). The filaments are purple, slender, and of varying length from 1.5-2 mm long (Dirr, 1998; Flora of China, n.d.; Walker, 1944).

The fruit is a woody capsule is two-valved, ovoid, and tannish-brown in color (Walker, 1944). The capsule is densely stellate-lepidote or puberulent (Walker, 1944). Each capsule is 1 cm long and holds one seed per valve (Walker, 1944; Dirr, 1998). The dehiscent capsule is held on a 2 mm pedicel, within an infructescence that is up to 4 cm long (Flora of China, n.d.; Walker, 1944). The seeds are shiny, ovoid, and 4-5 mm long (Flora of China, n.d.). The fruiting period is June to August (Flora of China, n.d.).

*D. racemosum* is native to Japan, Korea, Taiwan, and China (Flora of China, n.d.). Provinces in China include: Fujian, Hainan, and Zhejiang (Flora of China, n.d.). It is a locally dominant canopy tree in montane warm-temperate forests (Yamamoto, 1994). The hardiness of this species is not consistent between sources but Dirr (1998) believes it to be hardy to USDA Zone 6b. This species is not of conservation concern locally or globally and is not listed by the IUCN Red List. *D. racemosum* was the most reported species of the genus in the BGCI Collections Survey. The accessions reported in this data set were reported from 37 institutions from North America, Europe, Australia, and New Zealand. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 28 *Distylium racemosum*: BGCI Institution Report and BGCI Collections Survey

<i>Distylium racemosum</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	100	37
Countries	16	12
Accessions	N/A	79
Wild Provenance	N/A	13
Plants	N/A	109

#### 2.6.14 *Distylium tsiangii* Chun ex Walker

Original Publication: J. Arnold Arbor. 25: 330 1944

The *Flora of China* lists the local common name of *D. tsiangii* as “黔蚊母树” or “qian wen mu shu” (n.d.). *D. tsiangii* is an evergreen tree that grows to 7 m (Walker, 1944). Young stems are tomentose and ferruginous, mature branches are brown, glabrescent, and lenticellate (Flora of China, n.d.). The naked buds are brown, tomentose, and ovoid (Flora of China, n.d.). The leaves are elliptic to oblong-lanceolate, 10-15 cm long, and 4-5.5 cm wide (Walker, 1944; Flora of China, n.d.). The margin is entire or with 1-2 teeth towards the apex (Flora of China, n.d.). The base is acute or cuneate, and the apex is acute to acuminate (Walker, 1944; Flora of China, n.d.). There are 5-7 veins on each side of the mid-vein and these are raised abaxially (Flora of China, n.d.; Walker, 1944). The adaxial surface is lustrous and glabrescent, and abaxially the surface is light green with brown stellate pubescence (Walker, 1944; Flora of China, n.d.). The petiole is covered in dense stellate-pubescence and is 1-1.5 cm long (Walker, 1944).



The flowers were not observed by either Walker (1944) or the *Flora of China*. The infructescence is a raceme that is held on terminal shoots and is 3-5 cm long (Walker, 1944; Flora of China, n.d.). This structure is subtended by 2 or 3 basal leaves (Flora of China, n.d.). The pedicels are 2-4 cm long (Flora of China, n.d.). Capsules are ovoid, light gray, and densely tomentose (Walker, 1944; Flora of China, n.d.). The capsules are 1.2-1.7 cm long and dehisce by two, two-lobed valves (Walker, 1944; Flora of China, n.d.). Styles are persistent 3 mm long (Flora of China, n.d.). Seeds are 8-9 mm long, and the fruiting period is in July (Flora of China, n.d.).

*D. tsiangii* is native to the Guizhou province in China, in dense forests at elevations of 1,000-1,200 m (Flora of China, n.d.). This species is not of conservation concern locally or globally and is not listed by the IUCN Red List. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.15 *Distylium stellare* Kuntze**

Original Publication: Revis. Gen. Pl. 1: 233 1891

*D. stellare* is commonly called “angrit” in its native range in Indonesia (Mulyana, Kusmana, Budi R, & Wasis, 2017). It is an evergreen tree that grows to 13 m (Walker, 1944). The young stems are stellate-pubescent and mature to be glabrescent (Walker, 1944). The leaves are ovate to elliptic, or oblong-ovate, 4-8 cm long, and 2.5-4 cm long (Walker, 1944). The margins are entire, the base acute to obtuse, and the apex obtuse to acute (Walker, 1944). Adaxially the surface is shiny and glabrous with the midrib impressed (Walker, 1944). New growth is stellate-lepidote or puberulent on the adaxial surface, but matures to be glabrescent (Walker,

1944). The midrib and 5-6 vein pairs are prominent abaxially (Walker, 1944). The petiole is stellate-pubescent and 1 cm long (Walker, 1944).

The inflorescence is a spike, and holds either staminate or pistillate flowers (Walker, 1944). The staminate inflorescence is 0.4-0.5 cm long, and the pistillate inflorescence is 0.8-1.9 cm long (Walker, 1944). The bracts are ovate-oblong and 3 mm long (Walker, 1944). Walker notes the presence of lanceolate sepals that are 2 mm long and are stellate pubescent (Walker, 1944). Staminate flowers have 3-5 stamens per flower, with long filaments, and cordate-ovate anthers that are 2 mm long (Walker, 1944). The infructescence is 2 cm long and holds 1-4 capsules (Walker, 1944). Each capsule is 1-1.5 cm, sessile, and ovoid to subglobose (Walker, 1944).

*D. stellare* is not of conservation concern locally or globally and is not listed by the IUCN Red List. Mulyana et al. note that it is a dominant tree species in its native range in Indonesia, but that populations are impacted by illegal logging (2017). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.6.16 *Distylium* Cultivars**

Below is a cultivar list for this genus. Additional details for each cultivar are in Appendix A of this thesis.

*Distylium* ‘Frosty’

*Distylium* ‘Hawksridge Dwarf’

*Distylium* ‘Mr. Ishiâ’s Variegated’

*Distylium* ‘PIIDIST-I’

*Distylium* ‘PIIDIST-II’

*Distylium* ‘PIIDIST-III’

*Distylium* 'PIIDIST-IV'  
*Distylium* 'PIIDIST-V'  
*Distylium* 'Piroche Form'  
*Distylium* 'sPg-3-007'  
*Distylium* 'Spring Frost'  
*Distylium myricoides* 'Athens Tower'  
*Distylium myricoides* 'Carolina Compact'  
*Distylium myricoides* 'Lucky Charm'  
*Distylium myricoides* × *D. racemosum* 'Blue Cascade'  
*Distylium myricoides* × *D. racemosum* 'Vintage Jade'  
*Distylium racemosum* 'Akebono'  
*Distylium racemosum* 'Deep Red'  
*Distylium racemosum* 'Ed's Upright'  
*Distylium racemosum* 'Guppy'  
*Distylium racemosum* 'Hatsushimo'  
*Distylium racemosum* 'Pendula'  
*Distylium racemosum* 'Variegatum'  
*Distylium racemosum* × *D. myricoides* 'Emerald Heights'  
*Distylium racemosum* × *D. myricoides* 'Variegatum'

## 2.7 *Embolanthera* Overview [here](#)

**Nomenclature and Taxonomy:** The genus *Embolanthera* was introduced by Elmer Drew Merrill in 1909 from observations of a collection from Palawan in the Philippines (Li, 1943b). This single collection would later be named *E. spicata* Merr. (Li, 1943b). *Embolanthera* is in the subtribe Loropetalinae (Magallón, 2007). Endress

observed that all members of the Loropetalinae, excluding *Embolanthera*, have disc-shaped lobes that produce nectar (1989b). Most members of the Loropetalinae are pentamerous with the exception of *Loropetalum* which is tetramerous (Magallón-Puebla, Herendeen, & Endress, 1996). They also have anthers with two pollen sacs, which open by two valves, short styles, and elongated connectives (Li, Bogle, & Donoghue, 1999; Endress, 1989b). There are two species recognized in this genus, *E. glabrescens* H. L. Li and *E. spicata* Merr. (Bogle, & Philbrick, 1980). *E. glabrescens* has narrower leaves and fewer vein pairs than *E. spicata* (Li, 1943b). The genus is native to tropical and subtropical regions of the Philippines, southern China, and Vietnam (Li, 1997). No institutions reported housing either species of *Embolanthera* within their collections (BGCI, 2018). No cultivars were located for this genus in the literature.

**Description:** *Embolanthera* is a shrub or small tree characterized by a spicate inflorescence, petals with auriculate bases, petals and stamens that are fused at the base, and one ovule per carpel (IUCN, 1998; Li, 1943b; Li, 1997). Staminodes are absent, and the calyces are two or three lobed (Li, 1943b). Flowers are bisexual (Van Steenis, 1955-1958; Li, 1943b).

### **2.7.1 *Embolanthera glabrescens* H.L. Li**

Original Publication: Journal of the Arnold Arboretum. 24: 365, 1943.

*E. glabrescens* is a shrub or small tree with slender young stems that are dark brown in color (Li, 1943b). Older branches are smooth and gray-brown (Li, 1943b). Leaves are lanceolate to oblong-lanceolate, 7-12 cm long, and 1.5-4 cm wide (Li, 1943b). Li describes the margins as entire, the base as asymmetric with one side rounded and the other acute (1943b). Leaves have 5-7 vein pairs, and the petioles are

2.5 mm long (Li, 1943b). The shorter petioles of *E. glabrescens* help distinguish it from *E. spicata* (Li, 1943b).

Flower spikes are held terminally and are glabrous, these characteristics also distinguish *E. glabrescens* from *E. spicata* (Li, 1943b). This inflorescence is solitary and 8-12 cm long, with a 1-1.5 cm peduncle (Li, 1943b). Li, & Bogle describe the sepals as being fused into a tubular structure that ruptures when the flower is mature (2001). This trait is found in both *Embolanthera* and *Maingaya* (Li, & Bogle 2001). *E. glabrescens* is perigynous (Li, 1943b). *Embolanthera* has two cylindrical styles, each being 6 mm long, smooth, and with an acuminate tip (Li, 1943b). Fruit is a capsule that is 8-10 mm and black, and the endocarp is horned (Li, 1943b).

Bogle, & Philbrick (1980) state that the native range is a single location in north Vietnam, and Li states that the discovery of *E. glabrescens* greatly expanded the range of *Embolanthera* beyond the Philippines (1943b). An isotype held by the Muséum National d'Historie Naturelle, in Paris, France further supports this as it was collected by W. T. Tsang in 1940 in the Tonkin region of north Vietnam (Tsang, P00749043, 1940). *E. glabrescens* is not listed by the IUCN Red List. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.7.2 *Embolanthera spicata* Merr.**

Original Publication: Philippine Journal of Science, C 4: 263, 1909

In its native range, *E. spicata* is commonly referred to as “paningit” (Republic of the Philippines Department of Environment and Natural Resources (PDENR), 2017). The type specimen was collected in 1906 from Victoria Peak in the Philippines (Pelser, 2017). In 1957, Vink stated that “this remarkable plant has been found twice

only”. *E. spicata* is an evergreen subtropical to tropical tree that grows to 10 m (IUCN, 1998; Pelsner, 2017). Stems are slender, gray to brown, slightly lenticellate, and rounded when cut in cross section (Vink, 1957). The leaf arrangement is alternate, leaves are ovate or oblong, 7-10 cm long, and 2-5 cm wide (Vink, 1957). Margins are entire, recurved, and often apically denticulate (Van Steenis, 1955-1958; Vink, 1957). A digitized voucher examined had only entire margins (Foxworthy 00097354, 1906). The base is rounded to acute, and like *E. glabrescens* somewhat asymmetric (Vink, 1957). The voucher observed showed the acute leaf base, but not the asymmetric trait (Foxworthy). The apex is described and observed as acuminate (Vink, 1957; Foxworthy, 1906). *E. spicata* has 7-8 vein pairs that are prominent abaxially (Vink, 1957). Petioles are 5-10 mm long, and stipules are 5 mm long, lanceolate, and deciduous (Vink, 1957). Small scars are left where the stipules were attached (Van Steenis, 1955-158).

Flowers are white and sessile with linear to spatulate petals that are 2 cm long and 1.8-2 mm wide (Van Steenis, 1955-1958; Vink, 1957). The base of each petal has two lateral lobes. The inflorescence is an axillary spike that is 3-8 cm long and 2.5 cm in diameter (Van Steenis 1955-1958, Vink, 1957). The rachis and bracteoles are both pubescent (Vink, 1957). The calyx is connate and short, and is persistent in anthesis (Van Steenis, 1955-1958; Vink, 1957). The ovary is inferior, with two cells that contain one pendant ovule each (Van Steenis, 1955-1958). Each flower has two slightly decurrent styles that are less than 1 mm and slender (Van Steenis, 1955-1958; Vink, 1957). There are five stamens per flower with filaments that are very short and stout, anthers that have four pollen sacs, and are two-celled, dehiscing laterally with four valves (Vink, 1957; Van Steenis, 1955-1958). Van Steenis describes the

connective as extending into an “adaxial, subulate awn”, which is somewhat distinct (1955-1958). Staminodes are lacking (Van Steenis 1955-1958). Neither Van Steenis nor Vink had descriptions of the fruit (1955-1958; 1957). No fruit descriptions were able to be located for this thesis.

*E. spicata* is endemic to the island of Palawan in the Philippines, and only five populations are known (Bogle, & Philbrick, 1980; Pelser, 2017). It is found along streams and rocky riverbanks at elevations of 50-250 m (Pelser, 2017). The IUCN Red List states *E. spicata* is “Vulnerable D2”, this was assessed in 1998 and needs updating. The *Threatened Philippine Plants* lists it as a “Category C” plant which is described as “endangered” (Department of Environment and Natural Resources, n.d.; Republic of the Philippines Department of Environment and Natural Resources, 2017). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

## 2.8 *Eustigma* Overview

**Nomenclature and Taxonomy:** The genus name *Eustigma* is in reference to the enlarged stigma, a characteristic present in each of the four species within the genus (Toyama Tagane, Yahara, Dang, Tran, Nagamasu, & Naiki, 2016). *Eustigma*, *Molinadendron*, *Sinowilsonia*, and *Fortunearia* are in the tribe Eustigmateae within the Hamamelidoideae (Li et al., 1999; Rix, & Endress, 2016). *Eustigma* and *Fortunearia* are pentamerous and have lenticellate capsules (Li, Bogle, & Klein, 1997; Magallón, 2007). Until recently, only three species were recognized of *Eustigma*; *E. oblongifolium* Gardner & Champ., *E. lenticillatum* C.Y.Wu, and *E. balansae* Oliv. (Toyama et al, 2016). In 2016, Toyama et al. published a description for a new species *E. honbaense* H. Toyana, Tagane, & V.S.Dang. *Eustigma* is native to China, Laos,

Taiwan and Vietnam (Toyama et al., 2016). The genus has a concentrated distribution in the limestone forests of China (Zhaoran, 1995). No cultivars were located in the literature of this genus.

**Description:** *Eustigma* is a tropical evergreen tree or shrub, with naked buds, and stellate pubescence on its branches (Zhaoran, 1995; Flora of China, n.d.). All species in the genus have small stipules (Flora of China, n.d.). Leaves are leather with pinnate venation, the number of lateral veins on each side can assist in identification (Flora of China, n.d.). The leaf margin is entire in all species except *E. oblongifolium*, which can be entire or dentate towards the apex (Flora of China, n.d.).

Flowers are complete (Bogle, & Philbrick, 1980), and have small unique yellow petals described as auriculate, geniculate, spatulate or “with two dorsal swellings” (Toyama et al., 2016; Bogle, & Philbrick, 1980). Despite their size, the petals are quite distinct, and combined with the enlarged purple stigma, they have subtle ornamental qualities (Flora of China, n.d.). Bogle describes the style as “greatly elongated” and suggests that this signifies “a specialized pollination mechanism” that has yet to be studied (1980). The flowers have five sepals, alternating with the five stamens (Endress, 1989). Endress was unsure of the number of staminodes, and Flora of China describes the staminodes as absent, and the filaments are very short (1989). There are two locules per theca, and two valves per theca (Endress, 1989). Flowers are arranged in a terminal raceme, and each raceme typically occurs on short lateral branches (Flora of China, n.d.).

For all species, the floral cup is stellately tomentose and turbinate in shape (Flora of China, n.d.). The ovary is almost inferior, and there is one ovule per locule (Flora of China, n.d.). The Flora of China described capsules as woody ovoid capsules



that “dehisce loculicidally by two, two-lobed valves”. The capsule characteristics are consistent with the family.

### **2.8.1 *Eustigma balansae* Oliv.**

Original Publication: Hooker's Icon. Pl. 20: t. 1954. 1891 (Apr 1891)

The Flora of China lists the common name as “he mao xiu xhu hua” or “褐毛秀柱花”. The specific epithet honors plantsman Benedict Balansa (1825-1891) who collected what is now the type specimen of this plant in the 1880’s on an expedition to Vietnam (International Plant Names Index, n.d.; Balansa K000704917, 1885-1889). This species was originally described from the Tonkin Province in China (Li, 1943). The Flora of China, and some vouchered specimens, site *Dystilium chingii* Chun ex Walker as a synonym to *E. balansae*. This plant is not known to be grown in cultivation.

In 1943, Li described *E. balansae* as a shrub growing to 6 m, and presently the Flora of China describes it as a tree growing to 16 m. The buds are brown and with tomentose pubescence (Flora of China). Abaxially, the leaf also has brown tomentose pubescence with veins that are somewhat prominent (Toyama, et al., 2016). The adaxial side is shiny, which helps distinguish it from *E. lenticillatum* (Flora of China, n.d.). Leaves are elliptic or oblong, 10-16 cm long, and 4-6 cm wide (Flora of China, n.d.). The entire margin helps distinguish this species from *E. oblongifolium*. The leaf base is obtuse or cuneate, and the apex is acuminate (Flora of China, n.d.). There are seven to eleven lateral veins on each side of the leaf, this is another distinguishing feature that separates *E. balansae* from *E. honbaense* (5-9 veins) and *E. oblongifolium* (6-8 veins) (Flora of China, n.d.). Petioles are short, 6-12 mm, brown, and stellately

tomentose (Flora of China, n.d.). Stipules are linear or lanceolate (Flora of China, n.d.).

Each flower has two leaf-like bracts that are ca. 1.5 cm long (*E. lenticillatum* and *E. oblongifolium* are three-bracteate), and abaxially are brown and stellately tomentose (Toyama, et al., 2016; Flora of China, n.d.). Both bracts and bracteoles are obovate in shape and 3 mm, sepals are just 1.8-2 mm long (Flora of China, n.d.). The full inflorescence is 4-7 cm, with a brown tomentose peduncle (Flora of China, n.d.). The floral cup and ovary both are stellately tomentose, the styles are glabrous and 6-8 mm in length (Flora of China, n.d.). Stamens are under 1.8 mm in length (Flora of China, n.d.). Flowering period is April to May (Flora of China, n.d.). The fruit of *E. balansae* is consistent in characteristics with the rest of the genus; capsule type, shape, and size are all overlapping ranges between the species. Fruiting period is from June to August (Flora of China, n.d.).

*E. balansae* was considered the only species of *Eustigma* present in Vietnam until the Toyama et al. publication of *E. honbaense* in 2016. The native range of *E. balansae* is also in China, in the provinces of Guangdong, Guangxi, and Yunnan (Flora of China, n.d.). Outside of the habitat information for the genus, *E. balansae* is found at elevations between 400 and 500 m (Flora of China, n.d.). This species is not listed on the IUCN Red List and is not listed on the National Red List of China. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.8.2 *Eustigma honbaense* H.Toyama, Tagane & V.S.Dang**

Original Publication: PhytoKeys 65: 49. 2016 (15 Jun 2016) (e-published)

As *E. honbaense* is so newly described, no common name was found for it in the literature. *E. honbaense* was found during botanical surveys in the Hon Ba Nature Reserve in the Khanh Hoa Province of Vietnam between 2013 and 2014 (Toyama et al., 2016). The specific epithet is in reference to the nature reserve where it was found (Toyama et al., 2016). This species is similar in appearance to *E. oblongifolium*, but is outside *E. oblongifolium*'s native range, and Toyama et al. assure that it has characteristics that are sufficiently distinct to warrant a new species (Toyama et al., 2016). Toyama et al. did utilize matK sequencing of *E. balansae*, *E. honbaense*, and *E. oblongifolium* (2016). They concluded that *E. honbaense* and *E. oblongifolium* differed in six bases of the total 781 bases in this gene, and that *E. honbaense* and *E. balansae* differed in five bases of 761 (Toyama et al., 2016). However, it should be noted that only three individuals were located, one mature enough for reproduction and two juveniles (Toyama et al., 2016).

*E. honbaense* is a tree that grows to 10 m, with yellow-green stems that mature to brown and become glabrescent (Toyama et al., 2016). Terminal buds are narrowly ovoid and naked, but Toyama et al. describe them as being covered with either paired stipules or immature leaves (2016). Axillary buds are also ovoid but are scaled with two scales positioned opposite each other and incompletely covering the new leaves (Toyama et al., 2016). The scales have dense brown stellate hairs (Toyama et al., 2016).

Leaves are elliptic to oblong, 6.5-21.5 cm long, and 2.2-8-5 cm wide, whereas *E. oblongifolium* is more lanceolate and the leaf size is in the smaller range of *E. honbaense* (Toyama et al., 2016). Leaves are leathery, with an entire margin, and glabrous on both surfaces (Toyama et al., 2016). However, abaxially the secondary

veins have sparse stellate hairs (Toyama et al., 2016). Veins are prominent only on the abaxial surface (Toyama et al., 2016). The leaf base is obtuse to cuneate, and the apex acuminate to rounded (Toyama et al., 2016). The petiole is 9-14 mm long with sparse brown stellate hairs (Toyama et al., 2016).

Toyama et al. did not observe flowers on any specimens, but immature fruits and capsules were observed (Toyama et al., 2016). Floral cups in young fruits are turbinate and 2-3 mm wide, with brown stellate hairs (Toyama et al., 2016). The ovary was two-locular, and ovules one per locule (Toyama et al., 2016). Fruiting pedicels are 5-8 mm long, and the peduncles are 1.2-4.5 cm long (Toyama et al., 2016). Both the pedicels and peduncles have brown stellate hairs (Toyama et al., 2016). The full infructescence of *E. honbaense* is 5-10 cm long, and only 3-5 cm long in *E. oblongifolium* (Toyama et al., 2016). The infructescence is a raceme positioned terminally and in leaf axils (Toyama et al., 2016). Fruit is a woody capsule with sparse brown stellate hairs, houses two seeds per capsule, and again the type, shape and size of the capsule is consistent with the rest of the genus (Toyama et al., 2016).

*E. honbaense* was found in evergreen forest margins along streamsides at 400 m elevation (Toyama et al., 2016). Toyama et al. used the criterion outlined by the IUCN Red List to estimate the conservation status of *E. honbaense*. Given that there are just three individuals in one locality, they believe it should be classified as “Critically Endangered” and that expeditions should be sent to Hon Ba Nature Reserve to scout for additional populations of *E. honbaense* (Toyama et al., 2016). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### 2.8.3 *Eustigma lenticillatum* C.Y.Wu

Original Publication: Fl. Yunnan. 1: 130. 1977

*E. lenticillatum* is given the common name Wary Eustigma in reference to the lenticels present on the stems and fruit (Flowers of India, n.d.). *E. stellatum* K,M.Feng ex C.Y.Wu and *Sycopsis griffithiana* are both considered synonyms of *E. lenticillatum* (The Plant List 1.1.; Flowers of India, n.d.). Although not known to be grown in cultivation, there is potential ornamental value. The Forestry Bureau Council of Agriculture in Taiwan states that “the bright yellow style and deep purple stigma create sharp contrast and make the flower very eye-catching” (2016).

*E. lenticillatum* is an evergreen tree that grows to 10m, with young branches that are pubescent (Flora of China, n.d.). The wood is used for furniture construction in parts of India (Flowers of India, n.d.). The leaf is elliptic, with an entire margin, and almost glabrescent lamina (Flowers of India, n.d.; Toyama et al., 2016). The base is broadly cuneate or obtuse, and the apex acute (Flora of China, n.d.). *E. lenticillatum* has 7-10 lateral veins on each side of the mid rib, and abaxially the veins have stellate pubescence (Flora of China, n.d.; Toyama et al., 2016). Petioles are 1-2 cm in length (Flowers of India, n.d.).

The flowers of *E. lenticillatum* are three-bracteate, helping to distinguish it from *E. balansae* (Toyama et al., 2016). Bracts are ca. 1 mm long (Flora of China, n.d.). Petals and sepals are small, styles are 3-4 mm, and stamens ca. 2 mm (Flora of China, n.d.). The peduncle is 5-10 mm, and the flowers are shortly pedicellate (Flora of China, n.d.). Flowering period is April to May (Flora of China, n.d.). The capsules are comparable to the other species in the genus, but have dense lenticels (Toyama et al., 2016). The fruiting pedicel expands to 8-10 mm, and the fruiting period is June to

August (Flora of China, n.d.). The seeds within the capsule are edible (Flowers of India, n.d.).

*E. lenticillatum* is native to forests in Southeast Yunnan and Northeast India, growing at elevations of 1,000 to 1,200 m (Flora of China, n.d.; Flowers of India, n.d.). Although it is not listed by the IUCN Red List, it is listed by the National Red List of China as “Endangered D”, class D is in reference to the small population size or limited distribution of the population (Biodiversity Committee, 2017). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

#### **2.8.4 *Eustigma oblongifolium* Gardner & Champ.**

Original Publication: Hooker’s J. Bot. Kew Gard. Misc. 1: 312. 1849

*E. oblongifolium* is commonly known as the “Oblong-leaved Eustigma” (Hong Kong Herbarium, n.d.). It is common to see a misspelling “*E. oblongifolia*” in the literature, but the accepted suffix is “-ium” (International Plant Names Index, n.d.). An herbarium specimen at the Smithsonian National Museum of Natural History was initially labelled incorrectly as *Distylium tsiangii* Chun ex E. Walker (first published in 1944). Since *E. oblongifolium* was published in 1849, and this voucher was collected in 1930 it is believed that this is a case of misidentification, and not one of synonymy. *E. oblongifolium* is described by the Plantes et Botanique (2005) as being a tree or shrub to 8 m., and Li, & Hsieh describe it as a tree with a diameter of 30 cm (n.d.). The Flora of China describes young branches as glabrescent, “with older growth drying to a gray-brown and lenticellate” (n.d.). Li, & Hsieh describe branching as crowded and the bark as smooth (n.d.).

Like the other species in this genus, leaves are evergreen, leathery, and glabrescent on all parts but the abaxial secondary veins (Toyama et al., 2016). Leaves are oblong-lanceolate, with an entire margin that can be dentate apically (Toyama et al., 2016). The base is obtuse to cuneate, with an acuminate apex (Plantes et Botanique, 2005). Adaxially, the leaves are moderately shiny, and abaxially the venation is apparent (Flora of China, n.d.). Petioles are 5-10 mm long, and stipules are linear (Flora of China, n.d.).

Li, & Hsieh state that the flowers are bisexual and that the inflorescence is a 2 cm raceme covered in small scales (n.d.). Like *E. lenticillatum*, *E. oblongifolium* has three-bracteate flowers, but with bracts that are stellately pubescent and 1-1.2 cm (Toyama et al., 2016; Flora of China, n.d.). Petals are obovate and under 2 cm, the apex of each petal is two-lobed, giving it a unique shape (Flora of China, n.d.). Styles are 8-12 mm, anthers are ovoid and under 1 mm, and the floral cup is 2-2.5 mm with stellate pubescence (Flora of China, n.d.). The peduncle is initially covered in small hairs and just 6-8 mm long (Flora of China, n.d.). Flowering period is April to June (Flora of China, n.d.). Ovoid capsules are mostly smooth, but can have some lenticels, and are up to 2 cm long (Toyama et al., 2016; Plantes et Botanique, 2005). The infructescence expands to 3-5 cm long (Toyama et al., 2016). Seeds are elliptic, shiny, and black, much like other members of both the genus and the family (Li, & Hsieh, n.d.). Fruiting period is July to September, slightly later than the other species in the genus (Flora of China, n.d.).

*E. oblongifolium* is endemic to China, and can be found in; Fujina, Guangdong, Guanxi, Hainan, South Jiangxi, and Taiwan (Flora of China, n.d.). It grows at elevations of 100-200 m (Flora of China, n.d.). The IUCN Red List and the

National Red List of China do not list *E. oblongifolium* as being of conservation concern. However, the authors of the paper *Vegetation Diversity in the North Watershed of Peikang River* stated that *E. oblongifolium* was part of the “rare species” found in their survey (Chen, Chen, Chen, & Lo, 2005). The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections. The single reporting institution is in Australia.

[Table 29 *Eustigma oblongifolium*: BGCI Institution Report and BGCI Collections Survey

<i>Eustigma oblongifolium</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

## 2.9 *Exbucklandia* Overview

**Nomenclature and Taxonomy:** The genus name has a convoluted history, originally named for Reverend William Buckland in 1832 by Robert Brown. Seven years prior to that publication, the botanist Jan Svatopluk Presl had named a genus of fossil cycadioids *Bucklandia* (Jacobson, 2009). This duplication was not corrected until 1946 when it was changed to “the inelegant but necessary name” *Exbucklandia* (Jacobson, 2009). A proposal to change the genus name to *Symingtonia* was brought forth in 1952, possibly in response to Robert Brown not citing the place of publication when replacing *Bucklandia* with *Exbucklandia* (Jacobson, 2009; The Plant List 1.1.).



The *Symingtonia* proposal was rejected since the rule requiring the citation of publication place only applies to names published after January 1, 1953 (Flora of China, n.d.).

There are three well-supported species within this genus; *E. longipetala*, *E. populnea*, and *E. tonkinensis*. However, most sources reference there being four species in the genus but fail to list all four species that they would include within *Exbucklandia* (Huang et al., 2017; Wu et al., 2009; Flora of China, n.d.). The Plant List 1.1 does list an unresolved name of *Exbucklandia stellatum*. Nowhere in the literature is it recorded that *E. stellatum* is the fourth species that those three sources reference.

Due to the direct correlation between precipitation and drip-tip length (lamina apex), *Exbucklandia* sp. fossils can be used to create paleo-climate models (Wu et al., 2009). Using this genus for modelling has encouraged prolific publication on leaf morphology of extinct and extant species within this genus. During the Miocene and Pliocene, *Exbucklandia* was found well outside of its extant range in other parts of China, as well as Western North America (Huang et al., 2017). These extinct fossilized specimens were able to be identified as unique species based upon comparisons of leaf and stipule morphology to modern specimens (Huang et al., 2017, Wu et al., 2009).

Although not commonly found in gardens, 17 institutions reported this genus in the BGCI Institution Report; most reports were of *E. populnea* but two institutions reported housing *E. tonkinensis*. Sources were able to be located that offer this genus for sale. No cultivars are believed to exist for this genus. The current IUCN Red List has not evaluated the conservation status of this genus.

**Description:** The genus is composed of evergreen trees that are native to broadleaved evergreen forests of southeast Asia. The range extends from India east to China, and south to Sumatra (Huang et al., 2017). There is overlap in the ranges of the three species (Huang et al., 2017). Stems in all species are stout with distinct nodes, and alternate arrangement (Flora of China, n.d.). Prominent ovate stipules are apparent on all species and help to distinguish between them (Huang et al., 2017). The stipules of *Exbucklandia* spp. are much larger than those of the related genus *Chunia* (Huang et al., 2017).

The leaf shape of *Exbucklandia* is distinct; a long petiole, leaf is leathery and thick, margin entire, palmately lobed on young leaves, with 3-5 distinct veins on all leaves. The apex is acuminate, and base can be cuneate, truncate, or even cordate in *E. populnea* (Huang et al., 2017). The anthers on *Exbucklandia* are two locular, which helps distinguish it from the closely related genera, *Mytilaria* and *Chunia* (Flora of China, n.d.).

### **2.9.1 *Exbucklandia longipetala* H.T. Chang**

Original Publication: H. T. Chang, Acta Sci. Nat. Univ. Sunyatseni. 1959(2): 33. 1959.

The *Flora of China* lists the common name as “chang ban ma ti he” or “长瓣马蹄荷”. Like all species in this genus, *E. longipetala* is not commonly found in cultivation. The habit is also consistent with the other species (medium sized tree with vase-shaped habit), and stems are thick as well, but the branchlets are glabrous and dry to a dark brown (Flora of China, n.d.). The buds are flattened from the sides with very small hairs, oblong-elliptic, 2-2.5 cm wide, and 1 cm long (Flora of China, n.d.). It is

unclear how the buds differ from other species, as no information was able to be located describing bud characteristics in the remaining species.

The foliage is evergreen and similar in size and shape to that of *E. tonkinensis*, Huang et al. also describes it as an intermediate between *E. tonkinensis* and *E. populnea* (2017). Examination of digital herbarium vouchers seems to indicate the two species are quite similar in leaf. Huang et al. created a reference chart of leaf shape and ratios for all of the known extant and extinct species in the genus (2017). This chart should be referenced for specific leaf morphology of *Exbucklandia*, *Chunia*, and *Mytilaria*. However, the chart does point out that *E. longipetala* tends to be more broadly ovate than *E. tonkinensis*, and *E. longipetala* is more ovate than *E. populnea* which has a characteristic round lamina (Huang et al., 2017). Both *E. longipetala* and *E. tonkinensis* have slender stipules and elongated drip tips that range from acuminate to cuspidate (Huang et al., 2017; Flora of China, n.d.). The Flora of China notes that the leaves have conspicuous palmate venation with 3-5 veins (Flora of China, n.d.). The petiole is 3 to 5 cm in length (Flora of China, n.d.).

*E. longipetala* is the only species in the genus that consistently has petals (Huang et al., 2017). The petals are a creamy white, 1-1.5 mm wide, and 10-12 mm long. The stamens are shorter than the petals (Flora of China, n.d.). Groups of 7 to 8 flowers form a capitate inflorescence that is spherical in shape (Flora of China, n.d.). Individual plants are bisexual, but it is unclear if the flowers themselves are perfect (Flora of China, n.d.). Flowering period is from May to June, followed by a fruiting period from August to October (Flora of China, n.d.). The winged seeds are smooth and sit in woody capsules that are 7-8 mm in length (Weathington, 2015). The capsules are reminiscent of other genera in this family, e.g. *Hamamelis*, but are

clustered into tight groups at the end of branches (personal observation). The stout peduncle is tomentose and 1-1.5 cm in length, this is quite long compared to the flower and capsule size (Flora of China, n.d.).

Upon researching this genus, it was noted that the JC Raulston Arboretum houses a large specimen of *E. populnea* adjacent to a public building. Pictures of this specimen were located online and it was immediately apparent that this specimen possessed true petals, and is most likely *E. longipetala*. It should be noted that the specimen at JC Raulston Arboretum is of significant size (approximately 5 meters in height) and is mature enough to flower. However, the winter of 2017 caused significant damage to this specimen.

Native to Southeast China and Vietnam, specifically the karst region in China's Guangxi and Guizhou provinces (Huang et al. 2017; Flora of China n.d.). In these regions, *E. longipetala* can be found in evergreen forests at about 1500 meters in altitude (Flora of China, n.d.). This range is much more limited in size compared to the other species and overlaps slightly with the range of both *E. tonkinensis* and *E. populnea* (Huang et al. 2017). The Flora of China lists this species as being "Vulnerable", while the current listing on the IUCN Red List is that of "Unassessed". No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.9.2 *Exbucklandia populnea* (R. Brown ex Griffith) R. W. Brown**

Original Publication: (R. Brown ex Griffith) R. W. Brown, J. Wash. Acad. Sci. 36: 348. 1946.

Common names for this species include Malayan aspen, evergreen aspen, and Pipli Tree (Weathington, 2015; Jacobson, 2009). In China, it is referred to as "ma ti

he” or “马蹄荷” (Flora of China, n.d.). The history of nomenclature for this species is mostly consists of inexact synonyms. The confusion surrounding the genus name did impact this species, as synonyms include; *Bucklandia populifolia* Hook. Fil. & Thomson, *B. populnea* R. Br. ex Griff. named in 1836, and *B. tricuspis* (Miq.) W. Theobald (Catalog of Life, IT IS, 26<sup>th</sup> Feb 2018). The species *Aeschynanthus esquirolii* H. Lév., is also listed as a synonym to *E. populnea* (Catalog of Life, IT IS, 26<sup>th</sup> Feb 2018). The specific epithet “*populnea*” means “like a poplar” (Jacobson, 2009).

*E. populnea* in its native range has many cultural uses. It is used as timber, sometimes grown in plantations, in India it is used to stabilize slopes or in reforestation, and is used in all manner of construction where it is not exposed to the elements; including veneer and plywood ("Useful tropical plants database", n.d.; Jacobson, 2009). Jacobson also notes that “the U.S. Bureau of Plant Introduction has recorded seven attempts to bring this species to the U.S. between 1914 and 1928”. *E. populnea* is used as an ornamental tree in parks and along roadsides in its native range "Useful tropical plants database", n.d.). In northeast India young shoots of *E. populnea* are used in salads, chutneys, and various dishes (Jacobson, 2009).

*E. populnea* can be found for sale in nurseries in the United States. Jacobson states that in 1999 nurseries that carried this species included; Sonoma Horticultural Nursery, Cistus, and Heronswood. Presently, Far Reaches Farm in Washington State, and Woodlanders in South Carolina offer this plant for sale as one-gallon plants. Juniper Level Botanic Gardens’ website features a journal entry from Tony Avent’s botanic exploration to Vietnam in 2005. In this journal entry he states that he collected

*E. populnea* in China in 1996, and then observed it in the wild on the 2005 Vietnam expedition (Juniper Level Botanic Gardens, n.d.).

Growing to 30 meters tall and 25 meters wide in the wild, *E. populnea* is a medium sized tree with a vase-like habit and a dense crown (Useful tropical plants database, n.d.; Woodlanders, Inc, n.d.; Flowers of India, n.d.). Stems are pubescent, and the bark is dark brown with vertical furrow and fine scales (Flora of China, n.d.; Flowers of India, n.d.).

Like the other species in this genus, the foliage is evergreen ("JC Raulston Arboretum," n.d.). *E. populnea* has the broadest leaf and broadest stipule of the three species, although overlap exists in the range and shape of leaves between them. *E. populnea* has a broad leaf, 9-13 cm wide, and 10-17 cm long (Flora of China, n.d.). The base is cordate to truncate, the margin is entire, and the apex is the shortest of the species but still acuminate (Huang et al., 2017). Young leaves are strongly three-lobed, and venation in all leaves is palmate with 5-7 pronounced vein pairs (Flora of China, n.d.). Adaxially the leaf is shiny and dries to a dark green, and abaxially the leaves are glabrous (Flora of China, n.d.). The petiole is 3-6 cm in length and can be even longer on young leaves (Flora of China, n.d.). Stipules are a distinct characteristic of all *Exbucklandia*. The stipules of *E. populnea* are elliptic to ovate, 2-3 cm in length, and can be very broad, up to 2 cm in width (Huang et al., 2017; Flora of China, n.d.). Huang et al. observed a consistent pattern in *E. populnea*; the narrower the stipule the narrower the drip-tip of the leaf. This relationship informs the aforementioned paleo-climate modelling based on the leaf morphology of *Exbucklandia*.

Flowering period is from May to July, and flowers are wind pollinated ("Useful tropical plants database", n.d.). Flowers are unisexual or bisexual. Female flowers lack petals and stamens, and the unisexual flowers lack sepals ("Flowers of India," n.d.). When stamens are present, they are consistently longer than petals, and can be 5 mm in length (Flora of China, n.d.). If petals are present, they are red to maroon and only 2-3 mm in length ("Woodlanders, Inc," n.d.). Flowers occur in capitate racemes in groups of 8-20 ("Flowers of India," n.d.; Flora of China, n.d.). The inflorescence is held on a 1-2 cm long peduncle that is pubescent (Flora of China, n.d.). The ovary is also pubescent and yellow-brown in color (Flora of China, n.d.).

Fruiting period is from August to October (Flora of China, n.d.). Fruits are woody capsules that are smaller than *E. tonkinensis*, being only 7-9 mm in length and 5-6 mm wide (Huang et al., 2017; Flora of China, n.d.). The capsules are smooth, and the top half dehisces (Flora of China, n.d.). Each cell in the capsule holds 6-8 seeds ("Flowers of India", n.d.). The bottom seeds in the capsule are narrowly winged ("Flowers of India", n.d.; Flora of China, n.d.).

*E. populnea* has the broadest distribution of the genus (Huang et al., 2017). It can be found in southern China (Guangxi, Guizhou and Xizang provinces), Bhutan, India, Indonesia, west Malaysia, Myanmar, Nepal, Sikkim, Thailand, and Vietnam (Flora of China, n.d.). It is an early successional plant, occurring on slopes in evergreen forests or montane rainforests (e.g. Himalayas to Sumatran mountains) (Huang et al., 2017). It can be found in full to part shade and is said to have a hardiness to USDA zone 9, and perhaps in sheltered sites can be grown in zone 7 ("Woodlanders, Inc," n.d.). In its native range, it is common, and it is not listed on the

IUCN Red List (“Useful tropical plants database,” n.d.). The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections.

Table 30 *Exbucklandia populnea*: BGCi Institution Report and BGCi Collections Survey

<i>Exbucklandia populnea</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	17	9
Countries	5	4
Accessions	N/A	11
Wild Provenance	N/A	8
Plants	N/A	15

### 2.9.3 *Exbucklandia stellatum*

Original Publication: Yunnan., 1: 130. pl. 33:3–6, 130, 1977

This species is listed as unresolved by *The Plant List* version 1.1. Outside of the original publication, which was not able to be acquired for this thesis, there were no references to this species found in the literature. *Flora of China* does state that there are “about four species” of *Exbucklandia*, but only lists three species; *E. populnea*, *E. tonkinensis*, and *E. longipetala* (*Flora of China*, n.d.).

### 2.9.4 *Exbucklandia tonkinensis* (Lecomte) H. T. Chang

Original Publication: (Lecomte) H. T. Chang, *Acta Sci. Nat. Univ. Sunyatseni*. 1959(2): 3. 1959

The *Flora of China* lists the common name as “daguo ma ti he” or “大果马蹄荷.” Some sources call all *Exbucklandia* “pipli” or “pipli tree” (literally translated to



“tree tree”), but that common name is in reference to the Bengali name for *E. populnea* and just expanded to the other species as they were discovered by western scientists. Synonyms for *E. tonkinensis* include the generic confusion found in the other species; *Bucklandia tonkinensis* Lecomte, and *Symingtonia tonkinensis* (Lecomte) Steenis ex Vink (Flora of China, n.d.). The specific epithet is in reference to the Tonkin region in the Red River Delta of north Vietnam, to which it is native (Mabberley, 2008).

This species is uncommon in cultivation, and only two institutions reported housing *E. tonkinensis* in their collections through the BGCI Institutions Report. Far Reaches Farm in the state of Washington is reported to grow *E. tonkinensis* ("Flora of Wonder", 2013). The owners were said to collect seed of this plant on one of their trips to Vietnam ("Flora of Wonder", 2013).

*E. tonkinensis* is an evergreen tree that grows up to 30 m (Flora of China, n.d.). Young stems are brown and pubescent, bark is gray-tan (Flora of China, n.d.). The glabrescent petiole is 3-5 cm in length (almost identical to other species in the genus) (Flora of China, n.d.). *E. tonkinensis* has the most slender lamina of the species in this genus, but still has a broadly cuneate base, and the apex is acute to acuminate terminating in a well-developed “drip tip” with an entire margin (Huang et al., 2017; Flora of China, n.d.). Leaves are palmate with 3-5 vein pairs, young leaves sometimes being three lobed (Flora of China, n.d.). Leaves are 8-13 cm long and 5-9 cm wide, almost identical to *E. longipetala* (Flora of China, n.d.). The leaves are glabrous abaxially, and shiny on the adaxial side (Flora of China, n.d.).

Photos from the *E. tonkinensis* at Far Reach Farm website show the adaxial side of leaves having distinct long hairs on a dark green leaf ("Flora of Wonder",

2013). These photos also show cuspidate apices on both young and old leaves ("Flora of Wonder", 2013). The leaf characteristics observed in the photo are not listed as unique traits of any species in the genus. The photos do show some species of *Exbucklandia* as the pronounced ovate to oblong stipule is a unique feature of the genus, and present in the photos. The stipules for *E. tonkinensis* are oblong, 2-4 cm in length, 0.8-1.3 cm wide, and are moderately pubescent (Flora of China, n.d.).

Flowering time is May to July, and the flowers are found in groups of 7-9 forming a capitate inflorescence (Flora of China, n.d.). Like *E. populnea*, *E. tonkinensis* typically lacks petals, but if present they are shorter than the stamen (8 mm), the petals being just 2-3 mm in length (Flora of China, n.d.). The peduncle is 1-1.5 cm, it is brown and tomentose (Flora of China, n.d.). The ovary is pubescent and yellow-brown in color (Flora of China, n.d.).

Fruiting period is from August to September, which is shorter than either *E. longipetala* or *E. populnea* (Flora of China, n.d.). The capsules on *E. tonkinensis* are significantly larger than the other species, being 10-15 mm in length and 6-8 mm in width (Huang et al., 2017; Flora of China, n.d.). Winged seeds are found in the lower part of the capsules (Flora of China, n.d.).

Huan et al. states that *E. tonkinensis* is native to "slopes and valleys in evergreen forests" in southeast China and Vietnam (2017). *E. tonkinensis* is listed as present in the flora of Heishiding, China which is site used for a census with Smithsonian Institute's "Global Earth Observatory Network" (Forest GEO Network, n.d.). From their climate data, *E. tonkinensis* is accustomed to temperatures as low as 10.6°C and lives in subtropical humid forests for at least part of its range (Forest GEO Network, n.d.). Hardiness estimates outside of this data were not able to be found in

the literature. Presently, the IUCN Red List does not list *E. tonkinensis* as being of conservation concern (IUCN Red List, 2018). The table below shows a summary of the two BGCi data sets for this taxon in *ex situ* collections.

Table 31 *Exbucklandia populnea*: BGCi Institution Report and BGCi Collections Survey

<i>Exbucklandia populnea</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	2	1
Countries	2	1
Accessions	N/A	1
Wild Provenance	N/A	1
Plants	N/A	1

## 2.10 *Fortunearia* Overview

**Nomenclature and Taxonomy:** *Fortunearia* is a genus of shrubs or small trees within the subfamily Hamamelidoideae, and the tribe Eustigmatheae (Manchester et al., 2009; Li et al., 1999). Vegetatively, *Fortunearia* is remarkably similar to *Sinowilsonia* in appearance, and genetic work supports that these two genera are closely related (Li et al., 1999). Distinguishing features are outlined under the species description. The genus was first discovered by western scientists during Ernest Henry Wilson’s plant exploration to China from 1907 to 1908 (Gapinski, 2015). On this expedition he made note of a plant that he hypothesized as being a male *Sinowilsonia*, a new species of *Sinowilsonia*, or a new genus entirely (Gapinski, 2015). Upon returning to the Arnold Arboretum, Wilson and Alfred Rehder reviewed vouchers of this new material and determined it to be a new genus (Gapinski, 2015). The genus

name honors Robert Fortune, a Scottish botanist that took part in plant explorations to China during the mid-1800s (Missouri Botanical Gardens, n.d.).

### **2.10.1 *Fortunearia sinensis* Rehd. et Wils.**

Original Publication: Pl. Wilson. (Sargent) 1(3): 428. 1913 (15 May 1913)

The *Flora of China* lists a common name of “niu bi shuan” or “牛鼻栓” for this species (n.d.). The specific epithet is in reference to *Fortunearia* being endemic to China (*Missouri Botanical Gardens*, n.d.). Weaver describes the plants as having little ornamental value and being rare in cultivation, and no cultivars of *Fortunearia* were found in the literature (1976). In 1976, Weaver hypothesized that this species is “no longer present in cultivation in this country”. The BGCI Collections Survey showed that 28 plants are currently in living collections in the U.S. and other parts of the world. These 28 plants represent 19 accessions, of which six are of known wild origin. All but two of the wild origin accessions are of unique provenance. Those two accessions are from Langya Mountain in the Anhui Province in China and are presently housed in one collection in The Netherlands and one collection in the United States.

*Fortunearia sinensis* is a shrub or understory tree that grows to 5 m tall (Fridgeir, Barbara, Johannes, & Reinhar, 2015; *Flora of China*, n.d.). Young branches have stellate pubescence that is gray-brown in color, older branches become glabrous and are sparsely lenticellate (*Flora of China*, n.d.). Buds are small, naked and also have stellate pubescence (*Flora of China*, n.d.). Leaves contain two substances that are valued for their use in medicinal ingredients; bergenin and fortunearioside (Wu, Yan, Zhou, & Chan, 2014). The latter being named in reference to the genus, therefore,

indirectly referencing Robert Fortune. Leaves are alternate and deciduous, 7-16 cm long, and 4-10 cm wide (Fridgeir et al., 2015; Flora of China, n.d.).

The leaves are obovate with a serrate to dentate margin (Smithsonian National Museum of Natural History, 1907; Flora of China, n.d.). Weaver describes the margin as having “teeth triangular in shape” which distinguishes *Fortunearia* from the bristle-like teeth present in *Sinowilsonia*, although no other sources referenced this as being a distinct difference (1976). The Flora of China describes the base as being rounded or obtuse. Observations made of an isotype collected by Wilson in 1907 concur with the base being rounded to obtuse but would add that most of the leaf bases on this sample were asymmetrical (Smithsonian National Museum of Natural History, 1907). The apex is acute to acuminate (Flora of China, n.d.; Smithsonian National Museum of Natural History, 1907).

On preserved specimens, veins are prominent abaxially (Smithsonian National Museum of Natural History, 1907). Venation is pinnate with 6 to 10 lateral veins on each side (Flora of China, n.d.). Just the midrib on the adaxial surface is pubescent, and the entire abaxial surface is villous (Flora of China, n.d.). The petiole is short, 4-10 mm in length, with scattered hairs (Flora of China, n.d.). Stipules are very small and linear in shape (Flora of China, n.d.). When stipules abscise small scars are left on the stem (Flora of China, n.d.).

The plants are usually monoecious, and the flowers are functionally unisexual (Magallón, 2007) but the nonfunctional organs are still present and greatly reduced (Magallón, 2007). Flowers are pentamerous; male flowers have larger anthers than in the female flowers, and they are red and moderately showy (Magallón, 2007; *Missouri Botanical Gardens*, n.d.). In female flowers, the carpels are slightly larger than in the

male flowers (Flora of China, n.d.). Petals are scale-like and narrowly lanceolate. Sepals are longer than the petals, 1.2-1.5 mm, are also lanceolate but have dense pubescence (Flora of China, n.d.). Bracts and bracteoles are also densely pubescent and lanceolate in shape (Flora of China, n.d.).

Flowers are arranged on terminal racemes on short lateral branches (Missouri Botanic Garden, n.d.; Flora of China, n.d.). The inflorescence is 4-8 cm in length (Flora of China, n.d.). Flowers are born on pedicels that are 1-2 mm in length, this feature distinguishes *Fortunearia* from the sessile flowers of *Sinowilsonia* (Flora of China, n.d.). Pedicels are stellately pubescent at all stages and elongate to 10 mm when fruiting (Flora of China, n.d.). The peduncle is 1-1.5 cm long (Flora of China, n.d.).

Another distinguishing feature of *Fortunearia* is the semi-inferior ovary, whereas *Sinowilsonia* has an almost superior ovary (Flora of the China, n.d.). The floral cup of *Fortunearia* is distinctly obconical, with one ovule per locule (Flora of China, n.d.). Styles are 1.5-2.5 mm in length, and the stigmas are large and decurrent (Flora of China, n.d.). There are 5 stamens per flower with very short filaments, anther thecae are 2-sporangiate, and anthers are less than 1 mm in length (Flora of China, n.d.). The flowering period is March to May (*Missouri Botanical Gardens*, n.d.).

Fruit is a brown woody capsule that has conspicuous lenticels (Flora of China, n.d.). The capsule is ovoid to globose and 1.2 to 1.5 cm in length with two valves that are 2-lobed. The capsules contain seeds that are narrowly ovoid, 8-10 mm long, and 5-6 mm wide. The capsules have loculicidal dehiscence (Flora of China, n.d.). Fruiting period is May to June (Flora of China, n.d.).

*Fortunearia* is endemic to Central and Eastern China (Wu, Yan, Zhou, & Chen, 2014). Specifically, it is native to Anhui, Henan, Hubei, Jiangzi, Shaanxi, Sichuan, and Zhejiang provinces (Flora of China, n.d.). It can be found in mixed mesophytic forests at elevations between 800 and 1,500 m (Fridgeir et al., 2015). The Missouri Botanic Garden Plant Finder states that it is hardy to USDA Zone 4 (n.d.). The IUCN Red List does not list this species as being of conservation concern. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 32 *Fortunearia sinensis*: BGCI Institution Report and BGCI Collections Survey

<i>Fortunearia sinensis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	33	14
Countries	10	5
Accessions	N/A	19
Wild Provenance	N/A	6
Plants	N/A	28

### 2.11 *Fothergilla* Overview

**Nomenclature and Taxonomy:** Dr Alexander Garden was the first to collect and describe *Fothergilla* (Weaver, 1969). Dr. Garden sent his specimens to Linnaeus for review, and the two chose to name it after their mutual acquaintance, Dr. John Fothergill, a naturalist and Quaker that sponsored collecting expeditions (Shillito, 1976). The genus name was first mentioned in 1753, but formal publication of the name was not until 1774 (Shillito, 1976). Weaver (1969) describes three invalid

synonyms to this genus name. These are; *Yongsonia* W. Young., *Fothergilla* Dumort., and *Fothergillia* Spreng (Weaver, 1969). These synonyms appeared in publications between 1783 and 1829, but still arise in more contemporary literature (Weaver, 1969).

Magallón (2007) places *Fothergilla* in the tribe Forthergilleae. Within the genus, there is much variation between individuals (Weaver, 1976). Weaver (1976) describes a seventy-year debate over the validity of *F. major*, *F. gardenii*, *F. monticola*, and *F. parvifolia*. Presently, only two species are recognized as valid, *F. major* and *F. gardenii* (Darke, 2008). Both species have been in cultivation in the United Kingdom and North America for about two centuries (Darke, 2008). These two species do hybridize to form *Fothergilla* × *intermedia* (Darke, 2008). The discovery of this hybrid is discussed in the species description of *F. ×intermedia*. There are upwards of 30 named cultivars in the genus *Fothergilla* and these are listed at the end of the species descriptions.

**Description:** *Fothergilla* is a deciduous shrub that can form dense clonal masses (Weaver, 1969). *Fothergilla* can grow up to 6.5 meters in height and can also be a diminutive plant growing to just 1 m (Weaver, 1969). The stems are stellately pubescent, and the mature bark is light gray and smooth (Flora of North America, 1993). The vegetative bud is naked with dense stellate pubescence, and the terminal bud is subtended by 2-4 scales and is either sessile or on a short stalk (Flora of North America, 1993).

The leaf arrangement is alternate, and the leaf size is a distinguishing feature between the two species (Weaver, 1969). The species in the Coastal Plain, *F. gardenii*, has smaller leaves than *F. major*, which is found at higher elevations (Weaver, 1969).



The leaf shape is typically elliptical or obovate, but can be oblong, ovate, or even orbicular (Weaver, 1969). Leaf margins range from coarsely crenate, to serrate, or even entire (Weaver, 1969). The base is helpful for identification, *F. major* has an asymmetrical base, and *F. gardenii* has a symmetrical leaf base (Flora of North America, 1993). The apex is rounded, acute, or obtuse (Flora of North America, 1993). The petioles are short, and the stipules are narrowly lanceolate to ovate and quickly deciduous (Flora of North America, 1993; Weaver, 1969). The leaves are often a blue-green during the growing season, and can have spectacular fall color ranging from yellow, orange, to red.

The flowers are fragrant and held in dense spikes (Weaver, 1969). The inflorescence is short-pedunculate and is held terminally and on short lateral shoots (Weaver, 1969). The lateral placement gives the appearance that the inflorescence is axillary (Weaver, 1969). Flowers are apetalous and bisexual, and the basal flowers are described as “functionally staminate” by the *Flora of North America* (1993). The calyx is 5-7 lobed and forms a shallow hypanthium (Flora of North America, 1993). The ovary is partially fused to the receptacle and is semi-inferior (Weaver, 1969). There are two styles that extend to be “horn-like” with the tips recurving (Flora of North America, 1993). There are 12-32 anthers per flower (Weaver, 1969). The filaments are the most ornamental part of the flower being white, numerous, and 4-17 mm long (Flora of North America, 1993). The anthers dehisce by two flaps, and the staminodes are entirely absent (Flora of North America, 1993).

The flowering period occurs before or with the leaves from March to May (Weaver, 1969). Flowering time is impacted by both geography, southern individuals blooming earlier, and elevation, higher elevation individuals blooming later (Weaver,

1969). The fruit is a woody capsule that is distally loculicidal (Flora of North America, 1993). Capsules are in groups of three or more, and each capsule holds two seeds that are red-brown in color, glossy, and up to 8 mm long (Flora of North America, 1993; Weaver, 1969). At maturity the capsule dehisces along a dorsal suture and is four-beaked (Weaver, 1969). Seeds require cool temperatures to break dormancy and often do not germinate until the second year (Van Dersal, 1938).

Weaver included in his 1969 publication his research on chromosomal counts of *Fothergilla*. He reported that the earliest available study on this topic was from Anderson and Sax in 1935. Anderson and Sax used accessioned specimens from the Arnold Arboretum, and a later study by Thomas also used specimens at the Arnold Arboretum for a similar study (Weaver, 1969). Thomas recorded the accession numbers of the plants he used in his study, which allowed Weaver to test these exact plants and additional specimens in his work (Weaver, 1969). Ultimately, Weaver determined that the cytological evidence only supported two species; *F. gardenii* and *F. major* (Weaver, 1969). Weaver (1969) also concluded that *F. gardenii* is a tetraploid, with 48 chromosomes, and *F. major* is a hexaploid, with 72 chromosomes. This led later researchers to describe a pentaploid hybrid of these two species, *F. ×intermedia*, which is discussed in detail under the species description.

*Fothergilla* is endemic to the southeast United States (Weaver, 1969). The two species are found in separate regions, the Coastal Plain and the Appalachian Mountains (Weaver, 1969). The ranges of the two species overlap in just two counties in North Carolina, but it is unclear if the populations themselves overlap within these counties (Kartesz, 2015). In the BGCI data sets, *Fothergilla* sp. or cultivars known just

to the genus level were reported. The table below shows a summary of the two BGCI data sets for *Fothergilla* sp. in *ex situ* collections.

Table 33 *Fothergilla* sp.: BGCI Institution Report and BGCI Collections Survey

<i>Fothergilla</i> sp.	BGCI Institution Report	BGCI Collections Survey
Institutions	18	13
Countries	3	4
Accessions	N/A	63
Wild Provenance	N/A	12
Plants	N/A	159

### 2.11.1 *Fothergilla gardenii* Murray

Original Publication: Linn. System. Veg. ed. 13. 418. 1774

*Fothergilla gardenii* is commonly called dwarf fothergilla or coastal fothergilla (Darke, 2008). Synonyms to *F. gardenii* include *Hamamelis virginiana carolina* L., *Fothergilla alnifolia* L.f., *F. alnifolia* f. *acuta* Ait., *F. alnifolia* var. *serotina* Sims, *F. carolina* (L.) Britton, and *F. parvifolia* Kearney (Weaver, 1969). The specific epithet “*gardenii*” is in honor of Scottish physician, Alexander Garden, whom resided in Charleston, South Carolina and was an enthusiastic plantsman and the first to discover the plant material that would become *Fothergilla* (Missouri Botanical Garden, n.d.).

*Fothergilla gardenii* is a deciduous shrub that grows solitary or in suckering masses (Flora of North America, 1993). Weaver (1969) states that the distal portions of the plant are often densely pubescent, and the proximal parts of the plant are commonly glabrous. *F. gardenii* is smaller than *F. major*, all sources state that the

maximum height of *F. gardenii* is under 1 m. Weaver (1969) describes mature flowering specimens as having stems that are 0.3-2 cm in diameter. Young stems are slender (Flora of North America, 1993).

The leaves are coriaceous, elliptic-oblong, obovate, or orbiculate (Flora of North America, 1993). Darke (2008) states that the leaves are 2-6 cm long and 1.5-5 cm wide, smaller than the leaves of *F. major*. The margins can be entire, undulate, coarsely crenate, or serrate-dentate (Weaver, 1969). When serration is present, this tends to occur towards the apical half of the leaf (Weaver, 1969). The individual teeth often terminate in short mucros (Weaver, 1969). The symmetrical leaf base distinguishes *F. gardenii* from *F. major* (Flora of North America, 1993). The apex is commonly acute or obtuse, but can be retuse or even emarginated (Weaver, 1969). The number of vein pairs is another identifying feature, *F. gardenii* having 4-5 vein pairs, and *F. major* having 5-6 pairs (Flora of North America, 1993). The adaxial surface is green, stellately pubescent, and the pubescence is yellow or rust colored (Flora of North America, 1993; Weaver, 1969). Abaxially the leaves are also stellately pubescent, and unlike *F. major*, the abaxial surface of *F. gardenii* is never glabrous (Weaver, 1969). The petiole is typically 3-8 mm long, but can be up to 12 mm, and has dense yellow pubescence (Flora of North America, 1993; Weaver, 1969). Stipules are lanceolate or ovate, 1.5-4 mm long, and covered in brown pubescence (Weaver, 1969). The pubescence can be moderate or very dense (Weaver, 1969).

Flowers of *F. gardenii* are white, apetalous, and are held in dense spikes that are 1.5-4.2 cm long and 1.5-3.5 cm wide (Weaver, 1969; Flora of North America 1993). The inflorescence is sessile or on a short peduncle that can be up to 6.2 mm

long (Weaver, 1969). Like other parts of the plant, the peduncle is covered in dense yellow pubescence (Weaver, 1969).

Individual flowers have sub-orbicular floral bracts that have dense, brown pubescence (Weaver, 1969). Weaver (1969) describes the lowermost bracts as 4.1-7.9 mm long and 2-6 mm wide. These are larger than the remaining bracts which are 2.2-5.1 mm long and 1.7-3.5 mm wide (Weaver, 1969). There are 5-7 minute partially fused sepals per flower, and at anthesis these are just 1 mm long (Weaver, 1969). Within an inflorescence, both male and female flowers are present (Darke, 2008). Only the male flowers have ornamental value, as their filaments are 4.5-12 mm long, white, and numerous, occurring in groups of 12 to 24 per flower (Darke, 2008; Weaver, 1969). The anthers are yellow, 0.5-1 mm long and 0.4-0.9 mm wide (Weaver, 1969). The styles and stigmas combined are 4.5-10.5 mm long, and the ovary is 1-2 mm long at anthesis and covered in dense, yellow pubescence (Weaver, 1969). Weaver (1969) describes *F. gardenii* flowers as having a hypanthium that is 1.5-2.6 mm wide at anthesis and, like the ovary, covered in dense, yellow pubescence. *F. gardenii* flowers before its leaves emerge from March to May (Flora of North America, 1993).

The infructescence is 2.3-4.3 cm long and 1.5-2 cm wide (Flora of North America, 1993). The fruit is a capsule that is 6.5-10.5 mm long, and can be as large as 13 mm long (Weaver, 1969). Each capsule holds two seeds which are 4.8-6.3 mm long and 2.3-3.2 mm wide (Weaver, 1969).

*F. gardenii* is found in pocosons, pine woods, swamps and bogs in the coastal plain of the United States in North Carolina, South Carolina, Georgia, Alabama, and the Florida pan handle (Darke, 2008; Flora of North America, 1993). It is found at

elevations between 0 and 185 m (Flora of North America, 1993). The habitat of the two species of *Fothergilla* is distinctly different, *F. major* being found at higher elevations on rocky slopes and piedmont mountains, this difference aids in identification (Flora of North America, 1993). In cultivation *F. gardenii* should be planted in acidic, well-drained, and moist soils, and should not be planted in heavy clay soils (Darke, 2008). It is hardy in USDA zones 5-8, and Darke (2008) states it is less reliably cold hardy than *F. major*. The Biota of North America classify it as rare in all counties within Alabama and Florida (Kartesz, 2015). Barger, Spaulding, and Holt (2013) state that it is globally rare and give it a “G3” ranking. Habitat loss, lack of prescribed burns, and drainage of wetlands are all cited as reasons for this ranking (Barger, Spaulding, & Holt, 2013). This species is not listed by the IUCN Red List. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 34 *Fothergilla gardenii*: BGCI Institution Report and BGCI Collections Survey

<i>Fothergilla gardenii</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	266	44
Countries	12	10
Accessions	N/A	443
Wild Provenance	N/A	63
Plants	N/A	1098

### 2.11.2 *Fothergilla major* G.Lodd.

Original Publication: Bot. Cab. 16: 6. T. 1520. 1829

*Fothergilla major* is commonly called the mountain fothergilla or large fothergilla, in reference to it growing at higher elevations in the Piedmont (Darke, 2008). Synonyms to *F. major* include; *F. alnifolia* var. *major* Sims, and *F. monticola* Ashe (Weaver, 1969). *F. monticola* was initially described as unique from *F. major* in that it was glabrous (Weaver, 1969). The cytological work of Thomas and Weaver helped determine that the glabrous characteristic alone did not warrant the species status of *F. monticola* (Darke, 2008).

*F. major* is a shrub that grows to 6 m (Darke, 2008). Plants are covered in stellate pubescence, and can form large suckering masses (Weaver, 1969; Darke, 2008). Weaver (1969) observed that flowering specimens had stem diameters of 0.3-3.5 cm, and the Flora of North America (1993) states that the branches are “robust”. Branches are completely glabrous in the proximal portions of the plant (Weaver, 1969).

The leaves of *F. major* are membranaceous, 2.5-13 cm long, and 1.8-11.2 cm wide (Weaver, 1969). These are variable in shape, but generally are elliptic, suborbicular, or obovate (Weaver, 1969; Darke, 2008). The lamina is less pubescent than that of *F. gardenii* (Darke, 2008). Leaf margins are entire, undulate, crenate, or serrate-dentate (Weaver, 1969). If the margin has serration, it is generally on the basal half of the leaf (Weaver, 1969). The leaf base is asymmetrical, a key identification feature, and is rounded, truncate and occasionally cuneate (Flora of North America, 1993). The apex can be shortly acuminate, rounded, or mucronate (Flora of North America, 1993). Weaver (1969) even describes the apex as occasionally emarginate. The *Flora of North America* (1993) states that *F. major* can be identified, in part, by the 5-6 vein pairs, but these are variable and can be as few as 4 and as many as 7,

overlapping with *F. gardenii*. Adaxially the leaves are green with yellow stellate pubescence at least on the veins, but most commonly on the entire surface (Flora of North America, 1993; Weaver, 1969). Abaxially the leaves are green, often glaucous, and have sparse to moderate stellate pubescence, which is yellow in color (Flora of North America, 1993; Weaver, 1969). The petioles also have dense yellow pubescence and are 3-15 mm long (Weaver, 1969). Stipules are lanceolate or ovate-lanceolate and 2.8-7 mm long (Weaver, 1969). In the growing season, the leaf color on some plants is a blue-green, and some cultivars have been selected for this trait. Fall color can be any combination of yellow, orange, crimson, or burgundy (Darke, 2008). Individual leaves can even display this full range of color (Dirr, 1998).

Like all characteristics of *F. major*, the inflorescence is larger on *F. major* than on *F. gardenii* (Darke, 2008). The inflorescence is a densely flowered spike that is 3-6 cm long and 2-3 cm wide (Flora of North America, 1993). The inflorescence can be sessile or shortly pedunculate (Flora of North America, 1993). If present, peduncles are covered in dense brown pubescence and can be up to 12 mm long (Weaver, 1969). The flowers are sweetly scented and apetalous (Weaver, 1969). Each flower has floral bracts which are suborbicular or broadly ovate, covered in brown pubescence, 4.1-12 mm long, and 3.5-8.8 mm wide (Weaver, 1969). The lobed calyx is persistent even when fruiting and is 0.4-1.6 mm at anthesis (Flora of North America, 1993; Weaver, 1969). Both the ovary and hypanthium have dense yellow pubescence, and at anthesis the ovary is 1.5-2.2 mm long and the hypanthium is 2.4-3.9 mm wide and 1.5-3 mm deep (Weaver, 1969). The styles and stigmas measured together are 6.2-12 mm long (Weaver, 1969). The numerous long anthers create the ornamental display of the inflorescence. Each flower has 22-34 stamens, and the white filaments are 6-17 mm



long (Flora of North America, 1993). The flowering period is from April to May, and in its native habitat it blooms later than *F. gardenii* (Flora of North America, 1993; Darke, 2008). Darke (2008) states that in cultivation the two species flower at the same time. Unlike *F. gardenii*, the flowers of *F. major* often appear with the emergence of leaves, and not distinctly before leaf emergence (Weaver, 1969).

The fruit is a “beaked” capsule with a persistent hypanthium. The capsule is 5.5-13 mm long and is held in small groups on an infructescence that is 3.5-7 cm long and 1.5-2.5 cm wide. Each capsule contains seeds that are 5-6 mm long with a pointed apex (Flora of North America, 1993).

*F. major* is distributed throughout the Blue Ridge and upper Piedmont of the United States in North Carolina, South Carolina, Tennessee, Georgia, and Alabama (Darke, 2008). Darke (2008) also reports a disjunct population in Arkansas. It is found on dry, rocky slopes, riverbanks, bluffs, and upper Piedmont mountains at elevations between 150-1,300 m (Weaver, 1969; Flora of North America, 1993). *F. major* grows in acidic, thin rocky soil *in situ*, and in cultivation does best in well-drained, acidic soil (Darke, 2008). This species is more cold tolerant than *F. gardenii*, and is hardy in USDA Zones 4-8 (Darke, 2008). Although it is not listed by the IUCN Red List, Zomlefer, Giannasi, Reynolds, and Heiman (2012) describe it as rare or threatened due to habit loss. Despite this threat, the BGCI data sets show that it is very prevalent in *ex situ* collections. The table below shows a summary of the two BGCI data sets.

[Table 35 *Fothergilla major*: BGCI Institution Report and BGCI Collections Survey

<i>Fothergilla major</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	207	55

Countries	20	14
Accessions	N/A	387
Wild Provenance	N/A	84
Plants	N/A	704

### 2.11.3 *Fothergilla ×intermedia* Ranney & Fantz

Original Publication: Hort Science 42: 472 2007

In the 1970's and 1980's within nurseries in the United States, both *F. major* and *F. gardenii* were being propagated, grown and sold (Darke, 2008). Due to the proximity of the two species in cultivation, cross pollination was possible. During this same period a more intermediate form of *Fothergilla* became available in the trade (Darke, 2008). Richard Weaver, having verified the chromosomal count for both species, hypothesized that this intermediate form was in fact a hybrid of the two species (Weaver, 1969). He spoke with Tom Ranney about this theory, and Ranney worked with colleagues to determine the ploidy counts of 17 *Fothergilla* in cultivation (Darke, 2008). Ranney determined that most of these taxa, and most of the taxa in cultivation, are pentaploids, with 60 chromosomes (Ranney et al., 2007). Ranney and his colleagues published the name *Fothergilla ×intermedia* to recognize it as a unique taxon (Ranney et al., 2007). As the name *F. ×intermedia* was published after the release of named cultivars of the observed intermediate form, it is common that cultivars in the trade are incorrectly named as *F. gardenii* or *F. major* (Ranney et al., 2007). Ranney et al. (2007) were able to make determinations about cultivars found in the trade at the time of their study, and clarifications are included in the cultivar checklist below. *F. ×intermedia* is intermediate in all characteristics and only reaches 1.5 m tall, this makes it very suitable for garden settings (Darke, 2008).

As *F. ×intermedia* is a hybrid of cultivated origins it is not listed as endangered by any source. The table below shows a summary of the two BGCI data sets for this taxon in *ex situ* collections.

[Table 36 *Fothergilla ×intermedia*: BGCI Institution Report and BGCI Collections Survey

<i>Fothergilla ×intermedia</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	78	28
Countries	4	5
Accessions	N/A	342
Wild Provenance	N/A	0
Plants	N/A	835

#### 2.11.4 *Fothergilla* Cultivars

The creation of distinct cultivars for the genus *Fothergilla* aided in the discovery of the hybrid *F. ×intermedia*, but it also created great confusion in the literature as to what cultivar name pairs with what species. As such, the cultivar list below is a summary of names located in the literature for the genus *Fothergilla*. Additional details for each cultivar are in Appendix A of this thesis.

*Fothergilla* ‘Hillier B’

*Fothergilla* ‘Kelly’s Select’

*Fothergilla* ‘Redneck Nation’

*Fothergilla ×intermedia* ‘Blue Shadow’

*Fothergilla ×intermedia* ‘Eastern Form’

*Fothergilla ×intermedia* ‘KLMfifteen’

*Fothergilla* × *intermedia* ‘KLMsixteen’  
*Fothergilla* × *intermedia* ‘KLMtwo’  
*Fothergilla* × *intermedia* ‘Mount Airy’  
*Fothergilla* × *intermedia* ‘Red Licorice’  
*Fothergilla* × *intermedia* ‘Sea Spray’  
*Fothergilla* × *intermedia* ‘Windy City’  
*Fothergilla gardenii* ‘Appalachia’  
*Fothergilla gardenii* ‘Bill’s True Dwarf’  
*Fothergilla gardenii* ‘Blue Mist’  
*Fothergilla gardenii* ‘Brian Upchurch’  
*Fothergilla gardenii* ‘Epstein Form’  
*Fothergilla gardenii* ‘Glaucophylla’  
*Fothergilla gardenii* ‘Harold Epstein’  
*Fothergilla gardenii* ‘Jane Platt’  
*Fothergilla gardenii* ‘Julia’  
*Fothergilla gardenii* ‘September Morn’  
*Fothergilla gardenii* ‘Suzanne’  
*Fothergilla gardenii* ‘Woodlanders’  
*Fothergilla gardenii* ‘Zundert’  
*Fothergilla major* ‘Arkansas Beauty’  
*Fothergilla major* ‘Black Mountain’  
*Fothergilla major* ‘Bulkyard’  
*Fothergilla major* ‘Feist Red’  
*Fothergilla major* ‘Huntsman’

*Fothergilla major* ‘KLMG’

*Fothergilla major* ‘Monticola’

## 2.12 Hamamelis Overview

As stated in the *Materials and Methods* section of this thesis, *Hamamelis* will not be treated in this thesis with the same rigor as the other genera in the family. Below is a list of commonly accepted species within the genus. See Appendix A for a list of resources related to *Hamamelis*. As the summary of data from the BGC Collections Survey and the BGC Institution Report are novel to this thesis, that data is included below under each species description. *Hamamelis* sp. or cultivars only known to the genus were common in both BGC data sets. The table below shows a summary of *Hamamelis* sp. in the BGC Institution Report and the BGC Collections Survey. Of the 238 plants reported in the BGC Collections Survey, 149 of these are of named cultivars. No cultivar list is included in this thesis for *Hamamelis* as this is the only genus with a designated ICRA. The Kalmthout Arboretum publishes an illustrated cultivar checklist for *Hamamelis* publicly on their website.

Table 37 *Hamamelis* sp.: BGC Institution Report and BGC Collections Survey

<i>Hamamelis</i> sp.	BGC Institution Report	BGC Collections Survey
Institutions	71	34
Countries	6	7
Accessions	N/A	196
Wild Provenance	N/A	3
Plants	N/A	238

### 2.12.1 *Hamamelis japonica* Siebold & Zucc

Original Publication: Abh. Math.-Phys. Cl. Königl. Bayer. Akad. Wiss. 4(2): 193 1845.

The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

Table 38 *Hamamelis japonica*: BGCI Institution Report and BGCI Collections Survey

<i>Hamamelis japonica</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	225	44
Countries	24	13
Accessions	N/A	208
Wild Provenance	N/A	26
Plants	N/A	254

### 2.12.2 *Hamamelis mexicana* Standl.

Original Publication: Publ. Field Mus. Nat. Hist., Bot. Ser. 17: 192 1937

This taxon is listed as unresolved by *The Plant List 1.1*, but is included here since it was reported in both BGCI data sets, and synonymy is not clear. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

Table 39 *Hamamelis mexicana*: BGCI Institution Report and BGCI Collections Survey

<i>Hamamelis mexicana</i>	BGCI Institution Report	BGCI Collections Survey
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Institutions	7	4
Countries	1	2
Accessions	N/A	10
Wild Provenance	N/A	4
Plants	N/A	10

### 2.12.3 *Hamamelis mollis* Oliv. ex F.B.Forbes & Hemsl.

Original Publication: Hooker's Icon. Pl. 18: t. 1742: xviii 1888

The table below shows a summary of the BGCi Institution Report and the BGCi Collections Survey for this taxon in *ex situ* collections.

Table 40 *Hamamelis mollis*: BGCi Institution Report and BGCi Collections Survey

<i>Hamamelis mollis</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	344	52
Countries	21	14
Accessions	N/A	354
Wild Provenance	N/A	9
Plants	N/A	442

### 2.12.4 *Hamamelis ovalis* S.W.Leonard

Original Publication: Sida 22: 850 2006

The table below shows a summary of the BGCi Institution Report and the BGCi Collections Survey for this taxon in *ex situ* collections.

Table 41 *Hamamelis ovalis*: BGCI Institution Report and BGCI Collections Survey

<i>Hamamelis ovalis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	19	12
Countries	2	2
Accessions	N/A	37
Wild Provenance	N/A	10
Plants	N/A	52

#### 2.12.5 *Hamamelis vernalis* Sarg.

Original Publication: Trees & Shrubs 2: 137 1911

The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

Table 42 *Hamamelis vernalis*: BGCI Institution Report and BGCI Collections Survey

<i>Hamamelis vernalis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	415	50
Countries	20	9
Accessions	N/A	573
Wild Provenance	N/A	53
Plants	N/A	910

#### 2.12.6 *Hamamelis virginiana* L.

Original Publication: Sp. Pl. 1: 124 1753



The table below shows a summary of the BGC I Institution Report and the BGC I Collections Survey for this taxon in *ex situ* collections. Note that the three accessions of the synonym *Hamamelis macrophylla* are included in this report.

Table 43 *Hamamelis virginiana*: BGC I Institution Report and BGC I Collections Survey

<i>Hamamelis virginiana</i>	BGC I Institution Report	BGC I Collections Survey
Institutions	320	59
Countries	27	12
Accessions	N/A	851
Wild Provenance	N/A	106
Plants	N/A	1522

#### 2.12.7 *Hamamelis ×intermedia* Rehder

Original Publication: J. Arnold Arbor. 26: 69 1945

The table below shows a summary of the BGC I Institution Report and the BGC I Collections Survey for this taxon in *ex situ* collections.

Table 44 *Hamamelis ×intermedia*: BGC I Institution Report and BGC I Collections Survey

<i>Hamamelis ×intermedia</i>	BGC I Institution Report	BGC I Collections Survey
Institutions	157	55
Countries	22	12
Accessions	N/A	1529

Wild Provenance	N/A	0
Plants	N/A	2214

### 2.13 *Loropetalum* Overview

**Nomenclature and Taxonomy:** The genus name *Loropetalum* comes from the Greek words “loros” meaning strap, and “petalon” meaning leaf or petal (Missouri Botanical Garden Plant Finder, n.d.). Initially some species (that currently are recognized as *Loropetalum*) were included in the genus *Hamamelis*, but in 1862 Daniel Oliver declared it a separate genus (Creech, 1998). The closely related genus *Tetrathyrium* was merged with *Loropetalum*, also by Daniel Oliver, in 1883 (Feng, Chen, Wang, Pan, Hong, 1999). This merge was not considered controversial as the type specimen for *Tetrathyrium* being referenced had shed its petals (Feng et al., 1999). The supposed characteristic lack of petals had been a defining reason to site *Tetrathyrium* as its own genus, and without it there was no strong reason to keep the genera separate (Feng et al., 1999). Feng et al. published a study in 1999 that confirmed this merging. Using morphology, PCR amplification, and ITS sequence divergence values they supported the recommendation for *Loropetalum* to include the genus *Tetrathyrium* (Feng et al., 1999). In 1989, Dr. Peter K. Endress created the subtribe, Loropetalinae to include the accepted genera *Loropetalum* and *Embolanthera*, as well as the unresolved *Maingaya* and the synonym *Tetrathyrium* (Feng et al., 1999; The Plant List, n.d.). More recently, Li, Bogle, & Klein have included the genus *Matudaea* in this subtribe as well (1999b). For most of its history *Loropetalum* has been described as a monotypic genus, but presently three species are recognized (Boyce, 2001). *L. chinense* (R. Br.) Oliv. is the most common and only cultivated species. *L. subcordatum* (Benth.) Oliver is not in cultivation but listed as

“Vulnerable” by the IUCN Red List, and *L. lanceum* Hand.-Mazz., also not found in cultivation, and is not assessed by the IUCN Red List (Krussmann, 1984; Flora of China, n.d.; Botanic Gardens Conservation International, n.d.). Cultivars were only located for *L. chinense* in the literature. These are listed after the species descriptions, and additional details for each cultivar are included in Appendix A.

**Description:** *Loropetalum* is a genus of shrubs or small trees that are evergreen, and sometimes semi-evergreen (Flora of China, n.d.; Bailey, 1949). The alternate leaves are ovate to oval, with an entire margin and pinnate venation (Flora of China, n.d.; O'Brien, 2004). Two distinct features of the leaf are the stellate-pubescence and the short petiole, both of which vary between species (Flora of China, n.d.; Bailey, 1949).

Floral details help to distinguish this genus from *Hamamelis* in that the thecae in *Loropetalum* are paired, and *Hamamelis* only has one per anther (Boyce, 2001). In addition, *Loropetalum* has a semi-inferior ovary whereas *Hamamelis* is fully inferior (Boyce, 2001). *Loropetalum* is bisexual and 4-5 merous, sometimes 6 (Feng et al., 1999). Flowers held terminally or axillary, and frequently both (Dirr, 1998; Flora of China, n.d.). The sessile flowers are held in clusters of 4 to 8 (Bailey, 1949). Strap shaped petals are white, pale yellow, or red (Flora of China, n.d.). Androecium characterized by 4 stamens, the filaments being notably short, nectar producing staminodes alternate with stamens (Bailey, 1949; Boyce, 2001). The flowering period for the genus is consistent with the family, producing flowers in late winter to early spring (Brickell, & Cathey, 2004).

The fruit of *Loropetalum* is a woody 2-seeded dehiscent capsule (Bailey, 1949). The fruiting pedicel is short or absent, and there is one seed per carpel with a

fleshy endosperm (Flora of China, n.d.). Buds are described as naked on all species by Flora of China. However, Michael Dirr describes the buds of *Loropetalum chinense* as being imbricately scaled (1998). This is discussed in greater detail in the *L. chinense* species description. The native range of the genus is from north-eastern India to southern China and Japan (Flora of China, n.d.). All three species of *Loropetalum* can be found in China, two of which are endemic (Flora of China, n.d.).

### **2.13.1 *Loropetalum chinense* (R. Br.) Oliv**

Original Publication: (R. Brown) Oliver, Trans. Linn. Soc. London, Bot. 23: 459. 1862

Originally described as *Hamamelis chinense* by Robert Brown in 1818, and deemed a unique genus by Oliver in 1862 (Feng et al., 1999, Flora of China, n.d.). Additional synonyms to *Loropetalum chinense* include; *Tetrathyrium simoaense* Y.Y. Qian, *Loropetalum indicum* Tong, and *L. subcapitatum* Chun ex H.T. Chang (Boyce, 2001; Feng et al., 1999). As stated, the separation of *Tetrathyrium* from *Loropetalum* was based on the mistaken lack of petals on the type specimen, when it was realized the plant did have petals, and the type was just missing them, *Tetrathyrium* was combined with *Loropetalum* (Feng et al., 1999). *Loropetalum indicum* has a tree-like habit and is native to the Khasia Hills in north-eastern India (Boyce, 2001). The habit and range were determined to be inadequate to warrant classifying it as a unique species, presently it is considered within the natural variation of *L. chinense* (Boyce, 2001). *Loropetalum subcapitatum* is also cited as an extreme variant of *L. chinense*, it is a larger tree than most *L. chinense*, growing in well preserved forests (Feng et al., 1999). The humid habitat that *L. subcapitatum* grows in is believed to account for the supposed larger glabrescent leaves (Feng et al., 1999). It should be noted that the

paratype of *L. subcapitatum* has small leaves (Feng et al., 1999). The variation in leaf size, presumably due to environmental influence, and the larger habit are insufficient to recognize *L. subcapitatum* as a unique species (Feng et al., 1999).

In 1880, Charles Maries brought *L. chinense* to Veitch Nursery in England, and in 1908 Frank Meyer, with the United States Department of Agriculture, introduced the species to the United States (Creech, 1998). Presently, *L. chinense* is commonly found in the nursery trade, and the only species of *Loropetalum* cultivated (Dirr, 1998; Boyce, 2001).

*Loropetalum chinense* is commonly called the Chinese Fringe-flower, or Chinese Fringe Flower (Dirr, 1998; (Missouri Botanical Garden, n.d.). In cultivation, *Loropetalum chinense* has a bushy or shrub-like habit, larger specimens can be more upright or vase-shaped (Krussman, 1984; Dirr, 1998). The Flora of China describes it as a shrub or small tree. Chinese and Japanese collections are described as shrubs, whereas collections from India are described as tree-like (Boyce, 2001). These observations are consistent with the characteristics of the synonyms described above. *L. chinense* in cultivation grows to a height of 1 m, with a width to 2 m (Krussman, 1984; Dirr, 1998). In their native habitat, *L. chinense* can reach 10 m in height, exhibited by the population in Ise Grand Shrine Forest, Japan (Dirr, 1998).

Slender branchlets are reddish brown with dense stellate pubescence (Bailey, 1949; Dirr, 1998; Flora of China, n.d.). Bark on old stems exfoliates in strips, but is hidden by the evergreen foliage (Dirr, 1998; Krussman, 1984). Buds are described as naked by the Flora of China, but Dirr describes them as "small, brown, and imbricately scaled" (Dirr, 1998). A specimen of *L. chinense* var. *rubrum* observed by the author in February 2018 at the University of Delaware Botanic Gardens had small,

brown buds with dense tan pubescence, with pairs of scales covering the preceding pairs rotated ninety-degrees. The buds ranged from 1-1.5 mm in length and 1.5-2 mm in width. To confirm this observation, the specimen was brought into a warm greenhouse to force bud breaking. Once the buds began to expand they were examined and dissected under a microscope. The bud scales were easily distinguished from leaf and flower primordia, confirming the initial observation that *L. chinense* has bud scales.

The leaves are ovate to elliptic, 2-6.5 cm in length and 1-3 cm in width (Flora of China, n.d.). The margin is finely toothed to entire (Flora of China, n.d.; Dirr, 1998). The leaf base is rounded and oblique (Bailey, 1949). Leaf apex is acute or shortly acuminate (Flora of China, n.d.). There are 4-8 lateral veins occurring on each side that are prominent abaxially (Flora of China, n.d.). The abaxial side is gray and stellately pubescent, which distinguishes it from the glabrescent *L. lanceum* (Flora of China, n.d.). Adaxially it is darker, with a rough texture and scattered stellate pubescence (Creech, 1998; Dirr, 1998). The petiole is 0.2-0.5 cm in length with stellate pubescence (Flora of China, n.d.). Stipules are triangular to lanceolate, have stellate pubescence, and are 3-5 cm in length (Flora of China, n.d.).

Flowers are white, pale yellow, or red, and sweetly scented (Flora of China, n.d.; Brickell, & Cathey, 2004). They are 4-5 merous, both being found on the same inflorescence in the field (Feng et al., 1999). Each petal is 1-2 cm in length, and the flower is 2 cm across (Flora of China, n.d.; Brickell, & Cathey, 2004). The pedicellate flowers occur in crowded cymes, in groups of 3-16 (Brickell, & Cathey, 2004; Flora of China, n.d.). The inflorescence is typically on short lateral branches positioned in the leaf axils (Flora of China, n.d.; Dirr, 1998). Sepals are ovate and 2-3 mm (Flora of

China, n.d.). The floral cup is cupular and stellately pubescent, 1.2-1.5 mm in length (Flora of China, n.d.). Stamens are in groups of 4 or 5 with very short filaments, and the scale-like staminodes alternate with the stamens (Flora of China, n.d.). The pedicel and outside of the calyx are both pubescent (Dirr, 1998). Flowers are bisexual (Yuan et al., 2015). Flowering occurs in late winter to early spring before the leaves appear (Dirr, 1998). The floral display lasts for 2-3 weeks (Dirr, 1998).

The fruiting period is from May to July (Flora of China, n.d.). Seeds are ovoid-globose or ellipsoid, 4-7 mm long, and 3.5-4 mm wide (Flora of China, n.d.). The seeds are held in a single nut-like woody capsules, each capsule holds two seeds (Flora of China, n.d.). Capsules are 7-8 mm long and 6-7 mm wide with brown stellate pubescence and are pedicellate, with a peduncle that is 8-10 mm in length (Flora of China, n.d.). The peduncle on *L. chinense* is longer than *L. lanceum* (Flora of China, n.d.). *L. chinense* has an inferior ovary that is stellately pubescent (Flora of China, n.d.). The persistent floral cup is 2/3-4/5 as long as the capsule (Flora of China, n.d.).

There are two varieties of *L. chinense* commonly recognized in the literature; *L. chinense* var. *chinense*, and *L. chinense* var. *rubrum* Yieh (Flora of China, n.d.). A third variety *L. chinense* var. *coloratum* C.Q. Huang was described in 2001 and is not commonly found in literature (Flora of China, n.d.).

*L. chinense* is native to China, India, and Japan and is a major component of the subtropical broad-leaved evergreen forests countries (Yuan et al., 2015). However, both Michael Dirr and John Creech state that only one population of *L. chinense* is present in Japan. This small population of just 10 trees is in the Ise Grand Shrine Forest (Creech, 1998). It is debated whether these are naturally occurring, or remnant descendants of plants brought from China (Creech, 1998). The

Flora of China describes the habitat of *L. chinense* as forests, thickets, and sunny hills at 1000-1200 m in elevation. In cultivation, it should be grown in full sun to part shade, and in acidic, moist, well-drained soils (Dirr, 1998). It has cold hardiness to zone 7, and risks injury below 0° F (Dirr, 1998).

Presently, *L. chinense* is not of conservation concern on the IUCN Red List, the National Key Protected Species list of China, or the 2015 Red Listed Plant of India (ICUN, China Plant List, India Red List). The National Red List of Japan, compiled by the Japan Integrated Biodiversity Information System in 2007, does list *L. chinense* as being “Critically Endangered”, most likely due to the small population size as mentioned by Dirr and Creech.

The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 45 *Loropetalum chinense*: BGCI Institution Report and BGCI Collections Survey

<i>Loropetalum chinense</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	246	38
Countries	17	10
Accessions	N/A	220
Wild Provenance	N/A	17
Plants	N/A	574

#### 2.13.1.1 *Loropetalum chinense* (R. Br.) Oliv. var. *chinense*

Flowers are white or pale yellow, 4-merous and sometimes 5-merous (Flora of China, n.d.; Feng et al., 1999). The inflorescence contains 3-16 flowers (Feng et al.,



1999). Fruit is 7-8 mm long and 6-7 mm wide, the same as the species (Feng et al., 1999). Leaf shape, size, and stellate pubescence is consistent with the species (Feng et al., 1999). The Flora of China states that Chinese populations occur in Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hubei, Hunan, Jiangsu, Sichuan, Yunnan, Zhejiang. It can also be found in northern India, and Japan (Flora of China, n.d.).

#### **2.13.1.2 *Loropetalum chinense* var. *coloratum* C.Q. Huang**

The original publication for this variety in its original language, Chinese: Bull. Bot. Res., Harbin 21(4): 508. 2001. No translation was able to be located for this paper.

#### **2.13.1.3 *Loropetalum chinense* var. *rubrum* Yieh**

*L. chinense* forma *rubra* was first recognized in the 1970's (Boyce, 2001). *L. chinense* forma *rubra*, as well as *L. chinense* var. *rubra*, are now considered synonyms to *L. chinense* var. *rubrum* (Boyce, 2001). The main difference between this and *L. chinense* var. *chinense*, is the deep pink to red flower color of *L. chinense* var. *rubrum* (Bao et al., 2007). These flowers are pendulous, 4-merous, sometimes 5-merous, and occur in groups of 3-16 on the inflorescence (Bao et al., 2007; Feng et al., 1999). The flowering time is variable, mostly occurring in spring (Bao et al., 2007). Bao et al. recorded flowering period for cultivated material and noted that two of their specimens flowered in fall, and one flowered in summer (2007). Sporadic flowering did occur as well in other accessions (Bao et al., 2007). Bao et al. note that this variety could potentially be bred for varying bloom times (2007). Fruit size and period is consistent with the species (Feng et al., 1999). The foliage on *L. chinense* var. *rubrum* is darker than species (Boyce, 2001). Bao et al. describes a large variation in the

foliage color including; purple, gray-purple, gray-orange, green, and yellow-green (2007).

This variety is a medium-sized shrub native to thickets in the Guangxi region, and Hunan Province in China (Bao et al., 2007; Flora of China, n.d.). It is a popular ornamental in China, Japan, and the United States (Bao et al., 2007). Bao et al states that it tolerates disease and insects and grows well in light shade to full sun (2007).

### **2.13.2 *Loropetalum lanceum* Hand.-Mazz**

Original Publication: Sinensia. 2(10): 123. 1932.

*Loropetalum lanceum* is a moderately sized tree growing from 9 to 13 m in evergreen forests on mountain slopes in southeastern China (Flora of China, n.d.). No common name is apparent beyond the local name “大果木继木” (da guo ji mu) which translates literally to "large fruit, wood following wood" possibly referencing the slightly larger capsule size of *L. lanceum* than other species (Boyce, 2001; Tropicos, n.d.). The young branches are pubescent, and the naked buds are stellately pubescent as well (Feng et al., 1999; Flora of China, n.d.). The glabrescent leaves are lanceolate to ovate-lanceolate with an entire margin (Flora of China, n.d.). The leaf shape differs from other species of *Loropetalum* and is the descriptive root for the specific epithet (Flora of China, n.d.). Leaf length is 5-8.5 cm, and width 2.5-3.5 cm (Flora of China, n.d.). The base is cuneate or obtuse, and the apex caudate to distinctly acuminate (Chinese virtual herbarium, n.d.). Adaxially the leaf is glabrous and pale or olive green (Chinese virtual herbarium, n.d.). Abaxial side of the leaf is leathery and glabrescent with somewhat prominent venation (Flora of China, n.d.)

*L. lanceum* also differs from other species in its number of floral characteristics, the flowers are mostly 4-merous, but can be 5-merous (Boyce, 2001).

Floral bracts are entire, the terminal inflorescence has 3 to 16 flowers and occur mostly on short lateral branches (Feng et al., 1999; Flora of China, n.d.). Sepals are ovate 2-2.5 mm, and petals are white 1-1.3 cm (Flora of China, n.d.). The peduncle is described as nearly sessile and is 0.3-0.5 cm (Flora of China, n.d.). Stamens short, filaments are equal length to anther (Flora of China, n.d.). The styles are very short and the ovary is tomentose (Flora of China, n.d.). Flowering occurs in March to May (Flora of China, n.d.).

The fruit is a greenish-brown pedicellate capsule 1-1.4 cm long, and 0.9-1 cm wide (Chinese virtual herbarium, n.d.; Feng et al., 1999). The globose capsules are stellately tomentose, and adnate to the floral cup for 2/3 to 3/4 of their length (Flora of China, n.d.). Fruiting period is from June to August (Flora of China, n.d.). Seeds ellipsoid, 7-8 mm (Flora of China, n.d.). This species is not listed as being of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.13.3 *Loropetalum subcordatum* (Benth.) Oliver**

Original Publication: Hooker's Icon. Pl. 15:t 1417. March 1883.

*Loropetalum subcordatum* is a shrub or small tree growing to 12 m in the Pearl River Watershed in southern China (Gong, 2010; Flora of China, n.d.). The Hong Kong Herbarium lists an English common name of "Hong Kong Witch-hazel", as well as a local common name "四药门花" (si yao men hua) which translates literally to "four medicinal flowers", possibly referencing historic uses for the plant (Chinese virtual herbarium, n.d.; Flora of China, n.d.). In 1861, George Benthham published the description for *Tetrathyrium subcordatum* Benth. or *T. subcordatum* Benth. (Boyce, 2001; Feng et al., 1999). Upon closer examination of the stigmatic lobes, it was

realized they had been mistakenly described as "subulate" when in fact they are coralloid, which is much more similar to *Loropetalum* (Feng et al., 1999). Presently, *Tetrathyrium* is recognized as a synonym to *Loropetalum* (Boyce, 2001).

The branchlets on *L. subcordatum* are glabrous and bright green (Flora of China, n.d.). The evergreen leaves are ovate to elliptic, 7-12 cm in length, and 3.5-5 cm in width (Flora of China, n.d.). The leaves of *L. subcordatum* are the largest of all *Loropetalum* species (Flora of China, n.d.). The leaves are ovate to elliptic, the base is rounded or subcordate (Flora of China, n.d.). The apex and margin are distinguishing characteristics, the apex is acute to acuminate, and the margin is entire, but can be sharply serrated to toothed starting  $\frac{1}{4}$  to  $\frac{3}{4}$  of the leaf length from the base (Flora of China, n.d.; visual description of herbarium specimen Flora of Kwangi). Venation differs from other species, 6-8 lateral veins on each side (Flora of China, n.d.). Veins are prominent abaxially. The adaxial side is glabrous, with impressed venation (Flora of China, n.d.). Petiole length is 1-1.5 cm, which is longer than other species (Flora of China, n.d.). The lanceolate stipules are a subtle 5-6 mm with stellate pubescence (Flora of China, n.d.).

The individual flowers are 5-merous with white, strap-like petals 1.5-2 cm in length (Flora of China, n.d.; Gu & Zhang, 2008). Flowers are held in axillary clusters in dense groups of 14-15 in "head-like" spikes (Feng et al., 1999). Bracts are linear, pectinate, and 3 mm in length (Feng et al., 1999; Flora of China, n.d.). Sepals are stellately pubescent and 1.5 cm in length (Flora of China, n.d.). Styles are 2 mm in length, much smaller than the length of the petals, and adding to the dense central dome of the overall flower structure with the petals loosely radiating (Flora of China, n.d.). Anthers are ovoid, and the staminodes divergent (Flora of China, n.d.).

Flowering time varies between populations, September to February, with peak flowering most typically in September to October but one of the four existing populations flowers April to May (Gong, 2010; Gu & Zhang, 2008). The Flora of China cites the flowering period as April to June. This discrepancy could be caused from only documenting the spring blooming population in Libo, Guizhou Province that was described by Gong (2010).

The fruit is a subglobose capsule 10-12 mm in diameter (Flora of China, n.d.). Capsules are sessile and adnate to the floral cup for  $\frac{1}{4}$  to  $\frac{1}{2}$  their length, these are clustered in a head (Flora of China, n.d.). The capsule being sessile and less adnate to the floral cup distinguishes *L. subcordatum* from the other two species (Flora of China, n.d.). Fruit set is documented as being very low, recruitment is as well (Gong, 2010). Autogamy is common (Gong, 2010). The Flora of China lists the fruiting period as July through August, but Gu & Zhang, 2008, cited that pollination of the fall blooming populations stimulates ovule growth in the following summer and sets fruit after the peak flowering of the next year in September to October (Gu & Zhang, 2008). Yuan-Qiu et al. note that *L. subcordatum* is pollinated by flies. Like other species, the ovary is pubescent, but *L. subcordatum* is noted for the presence of stellate hairs (2015; Flora of China, n.d.). Seeds are 6-7 mm (Flora of China, n.d.).

In 2010, Gong published a detailed paper on the four known populations of *L. subcordatum* and their genetics. These populations are found in Guizhou and Guangdong provinces, and the Hong Kong Special Administrative Region (Gong, 2010). The four populations combined account for a few dozen individuals of the taxa (Gong, 2010). A fifth population had been documented, but at the time of Gong's research, they were unable to locate it, and have declared it extinct from that site

(Gong, 2010). The existing populations occur in two distinct habitats that are sited in broadleaved evergreen forests of southern China. One population in Libo, Guizhou Province is in a dense forest, at a high altitude, on a Karst mountain (Gong, 2010). The other populations occur on damp streamside, in more light, at lower elevation, and are on the coast or island (Gong, 2010). In contrast to these habitats, Flora of China states that *L. subcordatum* is found on roadsides at 100-200 m in elevation, and the IUCN Red List describes the habitat as being confined to areas of rainforest at 590 m (Flora of China, n.d.; IUCN Red List 2018). This disparate habitat description could be due to analysis of only a handful of individuals, as they are very uncommon. Clearly the 1998 IUCN Red List data was published prior to Gong in 2010. But, it is unclear when the Flora of China published their data in relation to Gong's work. Given that the *Flora of China* cites this species as "Endangered" by the IUCN under the synonym *Tetrathyrium subcordatum* it can be assumed it was prior to Gong's publication.

*L. subcordatum* is presently listed as "Vulnerable" by the IUCN Red List's 1998 publication, it had been previously listed as "Rare". It is a Class II National Protected Species in China (Gong, 2010). Gong describes this as "one of the most endangered angiosperms in China". This description is not exaggeration, as one site has already become extinct, and the detailed genetic work of Gong showed that there is low genetic diversity within populations, and high genetic divergence between populations (Gong, 2010). Gong states that there is "an urgent need to carryout *in situ* conservation to preserve the four surviving populations of *L. subcordatum*" (Gong, 2010). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections. The two countries that

report this species in the BGCI Institution Report are Australia and China. Only China reported this species in the BGCI Collections Survey.

Table 46 *Loropetalum subcordatum*: BGCI Institution Report and BGCI Collections Survey

<i>Loropetalum subcordatum</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	1
Countries	2	1
Accessions	N/A	1
Wild Provenance	N/A	1
Plants	N/A	1

#### 2.13.4 *Loropetalum* Cultivars

Presently, *L. chinense* is the only species of *Loropetalum* in cultivation. Cultivars of this species are commonly confused, and recognized as having redundant characteristics (Creech, 1998). In a letter in September 1993, Randy Johnson states that this is due to the acquisition of similar plants from Asia at the same time and distributing this small pool of genetic material all over the United States (Creech, 1998). Once the plant material was distributed, it is unlikely the organizations would communicate with each other about potential introductions (Creech, 1998). For further information on the genetic relationships of specific cultivars see the publication by Dong et al. (January 01, 2014) titled *Genetic Relatives Analysis of 41 Loropetalum chinense var. rubrum Cultivars by ISSR Markers*. No doubt, some of the red or pink

flowering cultivars listed as *L. chinense* are in fact *L. chinense* var. *rubrum*. The cultivar list below is a tool for future researchers to use as a reference when formally creating a registration authority. Appendix A has additional details for each cultivar in this thesis.

*Loropetalum chinense* ‘Atropurpurea’

*Loropetalum chinense* ‘Bicolor’

*Loropetalum chinense* ‘Black Pearl’

*Loropetalum chinense* ‘Carolina Moonlight’

*Loropetalum chinense* ‘China Pink’

*Loropetalum chinense* ‘Ever Red’

*Loropetalum chinense* ‘Fire Glow’

*Loropetalum chinense* ‘Garnet Elf’

*Loropetalum chinense* ‘Garnet Fire’

*Loropetalum chinense* ‘Hillier Form’

*Loropetalum chinense* ‘Kurenai’

*Loropetalum chinense* ‘NC1002’

*Loropetalum chinense* ‘NC1002’

*Loropetalum chinense* ‘Peack’

*Loropetalum chinense* ‘Plum Gorgeous’

*Loropetalum chinense* ‘Purple Diamond’

*Loropetalum chinense* ‘Razzleberri’

*Loropetalum chinense* ‘Razzle-Dazzle’

*Loropetalum chinense* ‘Redin Black’

*Loropetalum chinense* ‘Roseum’



*Loropetalum chinense* 'Rubra'  
*Loropetalum chinense* 'Rubrum'  
*Loropetalum chinense* 'Ruby'  
*Loropetalum chinense* 'Shang-lo'  
*Loropetalum chinense* 'Shang-Red'  
*Loropetalum chinense* 'Shang-white'  
*Loropetalum chinense* 'Shidare'  
*Loropetalum chinense* 'Snow Muffin'  
*Loropetalum chinense* 'Snow Panda'  
*Loropetalum chinense* 'Snow Panda'  
*Loropetalum chinense* 'Snowmound'  
*Loropetalum chinense* 'Tang Dynasty'  
*Loropetalum chinense* 'Tokyo Weeping'  
*Loropetalum chinense* 'Variegated Form'  
*Loropetalum chinense* 'Zhouzhou Fuchsia'  
*Loropetalum chinense* Emerald Snow®  
*Loropetalum chinense* Pizzaz™  
*Loropetalum chinense* Snow Dance™  
*Loropetalum chinense* var. *rubrum* 'Bicolor'  
*Loropetalum chinense* var. *rubrum* 'Blush'  
*Loropetalum chinense* var. *rubrum* 'Burgundy Blast'  
*Loropetalum chinense* var. *rubrum* 'Burgundy'  
*Loropetalum chinense* var. *rubrum* 'Carolina Midnight'  
*Loropetalum chinense* var. *rubrum* 'Carolina Ruby'

*Loropetalum chinense* var. *rubrum* ‘Chang Nian Hong’  
*Loropetalum chinense* var. *rubrum* ‘Daruma’  
*Loropetalum chinense* var. *rubrum* ‘Daybreak’s Flame’  
*Loropetalum chinense* var. *rubrum* ‘Hindwarf’  
*Loropetalum chinense* var. *rubrum* ‘Hines Burgundy’  
*Loropetalum chinense* var. *rubrum* ‘Hines Purple’  
*Loropetalum chinense* var. *rubrum* ‘Monraz’  
*Loropetalum chinense* var. *rubrum* ‘Pink Pearl’  
*Loropetalum chinense* var. *rubrum* ‘Pipa’s Red’  
*Loropetalum chinense* var. *rubrum* ‘Piroche Form’  
*Loropetalum chinense* var. *rubrum* ‘Rons Black’  
*Loropetalum chinense* var. *rubrum* ‘Shang-hi’  
*Loropetalum chinense* var. *rubrum* ‘Sizzlin Pink’  
*Loropetalum chinense* var. *rubrum* ‘Sizzling Pink’  
*Loropetalum chinense* var. *rubrum* ‘Small Leaf Form’  
*Loropetalum chinense* var. *rubrum* ‘Suzanne’  
*Loropetalum chinense* var. *rubrum* ‘Variegated Form’  
*Loropetalum chinense* var. *rubrum* ‘Zhuzhou Fuchsia’  
*Loropetalum chinense* var. *rubrum* Fire Dance™  
*Loropetalum chinense* var. *rubrum* Plum Delight™

## 2.14 *Maingaya* Overview

**Nomenclature and Taxonomy:** Although *Maingaya* is listed as unresolved by *The Plant List 1.1*. Due to multiple sources treating *Maingaya* as an accepted genus, it is treated as such in this thesis. These sources include; Li, Bogle, and Klein (1999),

Magallón (2007), the IUCN Red List (Chua, 1998), the Harvard University Herbaria and Libraries (specimen 00293528), and four specimens from the Herbarium Catalogue of the Royal Botanic Gardens, Kew (K000704911, K000961818, K000704910, K000961819).

The genus name honors Alexander Carrol Maingay (1836-1869), a British botanist and physician that collected in Malaysia during the 19<sup>th</sup> century (International Plant Names Index, 2005). Specimens K000704911 and K000704910 were both collected by Maingay himself, but K000704911 incorrectly cites the collection year as 1871. This is assumed to be the received year of the specimen as Maingay died two years prior trying to calm a prison riot (Stafleu, & Cowan, 1981).

Although no digitized specimen is presently associated with the herbarium record 77483.000 at the Royal Botanic Gardens, Kew, the notes have been transcribed. These notes state genus *Maingaya* was believed to be extinct in the wild until the collection of 77483.000 by T.C. Whitmore. No collection date is recorded with that specimen. T.C. Whitmore lived from 1935 to 2002 (IPNI, 2005), and in 1971 collected specimen K000961819 of *M. malayana*. This narrows down the window of when his other specimen was collected. His notes also detail that 80 years prior to his collection of 77483.000 it was only known from a single collection in Penang. It is unclear if Whitmore was referencing Maingay's collections in Peninsular Malaysia; K000704910 and K000704911. Since the collection data is so limited it would be helpful to locate additional herbarium specimens or perhaps create modern vouchers of *M. malayana*.

*Maingaya* is in the subtribe Loropetalinae within the tribe Fothergilleae (Magallón, 2007; Mione, & Bogle, 1990). Mione and Bogle (1990) state that

*Maingaya* is the least specialized genus within this subtribe and that it retains different whorls of floral appendages found only in-part in the other members of the Loropetalinae. *Maingaya* is a monotypic genus with *M. malayana* Oliv. as the only species (The Plant List 1.1, n.d.). No cultivars are known of *Maingaya*.

#### **2.14.1 *Maingaya malayana* Oliv.**

Original Publication: Trans. Linn. Soc. London 28(4): 517. 1873 [after 3 Jul 1873, possibly 23 Aug]

*Maingaya* is a tree of unknown ultimate size (Chua, 1998). Notes from an herbarium voucher (Whitmore K000961819, 1971) state that the specimen was collected from a tree that grows to “90’, girth 7” (ca. 27 meters high and ca. 2 m in girth), and that it had smooth gray-brown bark. Notes from another voucher (Lesmy K000961818, 1991) state that the specimen was collected from a tree 30 m high with a 30 cm diameter at breast height, and that the bark was dark brown and smooth.

No leaf description was located for this species. The leaf description included here is based entirely on the combined observations of four digitized herbarium vouchers. The vouchers referenced were all from the online Herbarium Catalogue from the Royal Botanic Gardens, Kew (K000704911, K000961818, K000704910, K000961819). The leaf was observed to be ovate to narrowly elliptic, with a rounded base, and narrowly acute apex. Leaf dimensions were measured to be ca. 3.5-9 cm long and ca. 1.5-3.5 cm wide. The petioles are distinctly narrow and are ca. 1.5 cm long.

*Maingaya* is pentamerous, with five sepals, five stamens, and staminodia (Mione, & Bogle, 1990). All of these structures are whorled, and the innermost whorl contains ten sterile phyllomes (Mione, & Bogle, 1990). Voucher notes describe the

inflorescence as an umbel with yellowish perianth (Lesmy K000961818, 1991). The sepals are attached just below the top of the ovary, making it semi-inferior (Magallón-Puebla, Herendeen, & Endress, 1996). The fruit is described as “grey-green” and the seeds as black on the collection notes of an herbarium voucher (Lesmy K000961818, 1991). The capsule on an herbarium voucher was measured to be ca. 1 cm long with a ca. 0.5 cm long pedicel (Maingay K0007040911, 1871).

*M. malayana* is endemic to northeastern Malaysia (Li, Bogle, & Klein, 1999). It is found in primary rain forest at elevations up to 960 m (Chua, 1998). The collection notes from the most recent herbarium specimen (Lesmy K000961818, 1991) state that it was collected in a disturbed forest at 960 m in Penang, Malaysia. The IUCN Red List lists this species as “Vulnerable” (Chua, 1998). Residential and commercial development are cited as the main threats (Chua, 1998).

The table below shows a summary of the BGCi Institution Report and the BGCi Collections Survey for this taxon in *ex situ* collections. The institutions that reported this species in the BGCi Institution Report are in France, Malaysia, and the United Kingdom.

[Table 47 *Maingaya malayana*: BGCi Institution Report and BGCi Collections Survey

<i>Maingaya malayana</i>	BGCi Institution Report	BGCi Collections Survey
Institutions	3	0
Countries	3	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

## 2.15 *Matudaea* Overview

**Nomenclature and Taxonomy:** *Matudaea* is one of only two genera in the Hamamelidaceae found in Central America and is the only genus in the family found in South America (Silva-Arias, González, Tinjacá, & Chacón, 2015). Fossil records indicate that this genus was once present in central Europe by an extinct species, *M. menziesii* (Silva-Arias et al., 2015). The genus name is in reference to Eizi Matuda, a botanist born in Japan that emigrated to Mexico (Matuda MICH1192348, 1937). Eizi Matuda studied and described many Central American species, and numerous plants and animals were named in his honor (IPNI, 2005). Observations of herbarium vouchers of this genus found that most material was listed originally under the genus *Distylium* before the introduction of the name *Matudaea* in the 1930's (Matuda 100000275, 1937).

*Matudaea* is in the subfamily Hamamelidoideae, and is closely related to *Loropetalum* (Li, Bogle, & Klein, 1999b). Due to its close relationship to *Loropetalum*, *Matudaea* is in the subtribe Loropetalinae with *Embolanthera*, *Corylopsis* and the unresolved, *Maingaya* (Li et al., 1999b). Magallón outlines some of the main differences between *Matudaea* and the other members of the Loropetalinae citing that *Matudaea* has “moderate to long filaments, elongate anthers...less pronounced anther valves...a superior ovary, long styles with decurrent stigmas, and numerous stellate trichomes on stamens and carpels” (2007).

Two species of *Matudaea* are presently recognized, *M. colombiana* Lozano and *M. trinervia* Lundell (Silva-Arias et al., 2015). A third species, *M. hirsuta* Lundell, was described in 1961, but is presently considered unresolved (Every, 2009; The Plant List 1.1, n.d.). No sources were located indicating this genus is present in cultivation or that named cultivars exist of *Matudaea*.

**Description:** Sources with descriptions of this genus and its species are few. The descriptions for both the genus and each species are not adequate, and it is recommended that additional research be completed and published to provide the needed information.

*Matudaea* is a medium to tall tree growing to 25 m in height (Silva-Arias et al., 2015). Its evergreen leaves are alternate with distinct glandular hairs on the margins of its leaves (Every, 2009). Leaves have deep pinnate venation, and stipules are present (Every, 2009). The flowers are whitish in color, bisexual, and lack both petals and sepals (Every, 2009). A pair of fused bracts subtend the flower (Silva-Arias, et al., 2015; Every, 2009). Flowers are on condensed panicles, with each axis terminated by a flower, this characteristic is clearly demonstrated on observed herbarium vouchers (Every, 2009). The stigma is large and decurrent, and the stamens are grouped in clusters of 12-22 (Every, 2009; Silva-Arias et al., 2015). The anther has two valves per theca, which are quite recognizable in photographs that were observed (Byng, 2014). The flower is wind pollinated (Silva-Arias et al., 2015). The fruit is commonly a 1 (rarely 2) seeded woody capsule with valvate dehiscence (Li et al., 1999b; Silva-Arias et al., 2015).

### **2.15.1 *Matudaea colombiana* Lozano**

Original Publication: Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 20(78): 444–445, f. 1. 1996. (Revista Acad. Colomb. Ci. Exact.)

Silva et al. states *M. colombiana* is a medium to tall tree that only grows to 8 m (2015). Leaf descriptions are from this author's observations of various herbarium specimens, as no leaf descriptions were located. Leaves elliptic, 4-7 cm long and 1-2.5 cm wide (Tropicos 50089549, n.d.). The base is rounded to acute, apex acuminate, and

plinervy venation is distinct both adaxially and abaxially (Tropicos 50089549, n.d.). From observations of this one specimen, the inflorescence is held in leaf axils towards the end of each stem (Tropicos 50089549, n.d.). Translated notes from this same voucher include a description of the ovary and fruit stating it has a “yellowish ovary, peduncle and fruit with whitish tomentum, fruit is light green” (Tropicos 50089549, n.d.).

*M. colombiana* is native to the Colombian Andes (Silva-Arias, et al., 2015). Specifically, in the cordilleras at elevations between 1,500 and 2,200 m. The voucher referenced was collected in Colombia at an elevation of 1,750 m (Tropicos 50089549, n.d.). The habitat of *M. colombiana* is in cool upland regions or wet mixed forests (Every, 2009). No information was located to indicate that *M. colombiana* is of conservation concern. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.15.2 *Matudaea trinervia* Lundell**

Original Publication: *Lloydia* 3(3): 210. 1940. (Lloydia)

Silva-Arias et al. describe *M. trinervia* as a medium to tall tree growing 20-25 m (2015). Specimen notes from herbarium vouchers agree stating that it grows to 20 m, or 5-30 m (Tropicos 17740, 2018; Molina 17739, 1969). Stems are green, based on the author’s observations of another voucher (Gentry, n.d.). All leaf descriptions for this species are based on observations of multiple herbarium vouchers, including the type specimen. Leaves are narrowly ovate to elliptic, 5-13 cm long, and 2.5-5 cm wide (Matuda 100000275, 1937; Molina 17739, 1969; Ventura 17740, 1976). The leaf margin on all specimens is entire. The base is rounded or acute, and slightly asymmetrical (Matuda 100000275, 1937; Molina 17739, 1969). The apex was not



present on most vouchers, but the type specimen had an attenuate apex (Matuda 100000275, 1937). Plinervy venation was distinct on all samples, adaxially veins were sunken, and abaxially raised (Matuda 100000275, 1937; Molina 17739, 1969; Gentry, n.d.). The adaxial surface is shiny and dark green, and much paler abaxially (Matuda 100000275, 1937; Gentry, n.d.). The petiole was measured at 1-1.5 cm in length (Matuda 100000275, 1937; Molina 17739, 1969).

From observations of these same vouchers, the inflorescence is held in leaf axils towards the branch tips (Matuda 100000275, 1937; Molina 17739, 1969). Notes on two specimens state that the fruit is small and green (Ventura 12660, 1976; Tropicos 17740, 2018). The author confirmed this by direct observation of herbaria specimens. Additionally, fruits are ovoid, 1 cm wide and long, and are a cornute woody capsule with dense pubescence (Tropicos 17740, 2018; Ventura 12660, 1976; Gentry, n.d.). Like other members of the family, *M. trinervia* has a valvate split in its capsule for seed dispersal (Tropicos 17740, 2018).

*M. trinervia* is native to cool upland forests or wet mixed forests in Mexico and Costa Rica (Every, 2009; Silva-Arias et al., 2015). Vouchers observed were collected from Mt. Ovando in Chiapas, Mexico and the Veracruz Estate, Tocuapa, in the Municipality of Jalacingo (Matuda 100000275, 1937; Ventura 12660, 1976). Notes on one voucher indicated it was collected at just 550 m in elevation, much lower than where *M. colombiana* is found (Tropicos 17740, 2018). Another specimen's notes stated this species to be "Common in forest area between Pela Nariz and Calaveras" in Honduras (Molina 17739, 1969). Despite this observation, *M. trinervia* is considered "Vulnerable" by the IUCN Red List due to habitat decline, population fragmentation, and a lack of conservation strategies (Gonzalez-Espinosa, 1998). The table below

shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

Table 48 *Matudaea trinervia*: BGCI Institution Report and BGCI Collections Survey

<i>Matudaea trinervia</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	3	3
Countries	2	2
Accessions	N/A	6
Wild Provenance	N/A	3
Plants	N/A	9

## 2.16 *Molinadendron* Overview

**Nomenclature and Taxonomy:** *Molinadendron* is one of two genera in the Hamamelidaceae that is native to Central America (Every, 2009). Within the Hamamelidaceae it is in the subfamily Hamamelidoideae, the tribe Eustigmateae (Li, Bogle, & Klein, 1999). Other members of this same tribe are *Eustigma*, *Fortunearia* and *Sinowilsonia*, with *Molinadendron* being closely related to *Sinowilsonia* (Li et al., 1999). Although there are three species in the genus; *M. hondurensis* (Standl.) P.K. Endress, *M. sinaloense* (Standl. & Gentry) P.K. Endress, and *M. guatemalense* (Radlk. ex Harms) P.K. Endress, there is limited information on them in the literature, and there is little support in recognition of *M. hondurensis* as a valid species name (The Plant Lists 1.1.). There is no reference to this material being common in cultivation (The Plant List 1.1). The genus is native to cool upland regions or wet mixed forests

from Costa Rica to Mexico (Every, 2009; Byng, 2014). No cultivars of *Molinadendron* were found in the literature.

**Description:** *Molinadendron* is a genus of evergreen trees or shrubs (Every, 2009). The leaves have alternate arrangement, are simple with an entire margin, and have pinnate venation (Every, 2009). Leaves have stellate indumentum, and stipules are small and deciduous (Every, 2009). Petals are absent, and the bisexual flowers are born in a spike inflorescence (Every, 2009; Byng, 2014). Each flower has 5-9 stamens and two large decurrent stigmas (Byng 2014; Every, 2009). The anther has two valves per theca (Byng 2014). Fruit is a woody capsule, and carpels have just one ovule (Every, 2009). Every notes that galls are often present on plants in this genus (2009).

#### **2.16.1 *Molinadendron guatemalense* (Radlk. Ex Harms) P.K. Endress**

Original Publication: Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 89(3): 357. 1969. (Bot. Jahrb. Syst.)

As noted in the genus overview, very little information was found in the literature. As such, herbarium vouchers were used for all descriptions within this section. A type specimen collected in 1936 was collected under the name *Distylium guatemalense*, and an isotype collected in 1907 was also originally labelled as such (Yuncker, Dawson, & Youse 18380, 1936; Smithsonian 00097333, 2018). Presently, *Distylium guatemalense* is considered an invalid synonym.

The 1936 specimen of *M. guatemalense* was described on the notes as a 9 m tree with a trunk diameter of 20-25 cm (Yuncker, Dawson, & Youse 18380, 1936). Another specimen with better preserved leaves than the type had ovate leaves, with an acute base, and acuminate apex (Hazlett 21707, 1974). Despite Every describing the margins as entire, the observed specimen was sparsely toothed towards the apex

(Yuncker, Dawson, & Youse 18380, 1936). This same specimen held fruit which were ovoid and distinctly cornute (Yuncker, Dawson, & Youse 18380, 1936). Two of the specimens observed were collected in Honduras and one in Alta Verapaz, Guatemala. (Hazlett 21707, 1974; Yuncker, Dawson, & Youse 18380, 1936; Smithsonian 00097333, 2018). The type specimen notes state it was collected in “the hills above Siguatepeque in a wet ravine”, and another specimen notes that it was collected at 1350 m (Yuncker, Dawson, & Youse 18380, 1936; Smithsonian 00097333, 2018). These were the only habitat descriptions found in the literature. No institutions reported this taxon in either the BGC I Institution Report or the BGC I Collections Survey.

#### **2.16.2 *Molinadendron hondurens* (Standl.) P.K. Endress**

Original Publication: Bot. Jahrb. Syst. 89(3): 357. 1969 (14 Oct 1969)

“A tree of high-altitude mixed humid forests” (Nelson, 1998) is published in the International Plant Names Index as being accepted, and listed as accepted in The Plant List 1.1 (The International Plant Names Index, n.d.; The Plant List 1.1, n.d.) However, the Catalogue of Life lists it as a synonym to *M. guatemalense* (Radlk. ex Harms) P.K. Endress, and the Royal Botanic Gardens, Kew still list all vouchers of *M. hondurens* as a synonym to *M. guatemalense* (The Catalog of Life Partnership, n.d.; Royal Botanic Gardens, Kew, n.d.). The Global Biodiversity Information Facility lists 46 preserved specimens of *M. hondurens*, but lists these specimens as *M. guatemalense* (GBIF Secretariat, n.d.). All of these specimens were collected between 1994 and 2005 for the Plantae of Costa Rica (GBIF Secretariat, n.d.). The IUCN Red List lists *M. hondurens* as “Critically Endangered” (Nelson, 1998). No institutions

reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### 2.16.3 *Molinadendron sinoloanse* (Standl. & Gentry) P.K. Endress

Original Publication: Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie 89(3): 357, f. 2–6. 1969. (Bot. Jahrb. Syst.).

The specific epithet is in reference to the Sinoloa Province in Mexico to which the species is native (Smithsonian 00097335, 2018). Lee states that this species is “almost unknown” in cultivation (2006). *M. sinoloanse* is an evergreen tree that grows to 6 m (Lee, 2006). The leaves are 8-15 cm long and taper at the ends, they open purple to copper (Lee, 2006). The type specimen for this species was collected between 1,524 to 1,829 m in the Sinoloa Province of Mexico (Smithsonian 00097335, 2018). *M. sinoloanse* is not listed by the IUCN Red List. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

Table 49 *Molinadendron sinoloanse*: BGCI Institution Report and BGCI Collections Survey

<i>Molinadendron sinoloanse</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	3
Countries	1	2
Accessions	N/A	10
Wild Provenance	N/A	1

Plants	N/A	10
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## 2.17 *Mytilaria* Overview

**Nomenclature and Taxonomy:** *Mytilaria* was in the subfamily Exbucklandioideae (Endress, 1989). Other genera in this subfamily include; *Exbucklandia*, and *Chunia* (Magallón, 2007). However, ITS sequencing by Li, Bogle, and Klein (1999) support the monogeneric Mytilarioideae as described by Takhtajan (1997). Although not as closely related as once thought, in leaf these genera can be difficult to tell apart. They can be separated by many macro-morphological characteristics as described in the *Chunia* genus description earlier. *Mytilaria* also has stephanocytic stomata, unique in this subfamily (Wu, Sun, Liu, Xie, & Lin, 2009; Carper, 2005). This type of stomate is characterized by “weakly differentiated subsidiaries arranged in a rosette” as described by Carpenter (2005). The genus *Rhodoleia* also possess stephanocytic stomata, but *Rhodoleia* is in its own subfamily the Rhodoleioideae (Wu et al., 2005; Magallón, 2007). *Mytilaria* is a monospecific genus, *M. laosensis* being the only recognized species (Li, Bogle, and Klein, 1999). There are no known cultivars of *Mytilaria*.

### 2.17.1 *Mytilaria laosensis* Lec.

Original Publication: Bull. Mus. Nat. Hist. Nat. (Paris). 30: 504. 1924.

The Flora of China lists the common name of *Mytilaria laosensis* as “壳菜果属” or “ke cai guo shu”. It is used in highly productive plantations that produce good quality timber (Chen, Zeng, Jia, Zeng, Guo, & Cai, 2012; Liu, Huang, Luke, Zhou, Wan, Yu, & Zheng, 2017). Chen et al. also describe it being used for “ecological benefit-oriented forests” (2012).

*M. laosensis* is a broad-leaved evergreen tree with a very straight trunk (Chen et al., 2012; Flora of China, n.d.; Ming Jia, Zhao, Tao, & Li, 2014). The Flora of China states that these trees grow up to 20 m, and the original author of *M. laosensis*, Paul Henri Lecomte, states they grow to 30 m (Flora of China, n.d.; Lecomte, 1924). A study done on the soil organic carbon cycling in broadleaved plantations found that the average height of *M. laosensis* in their test plots to be 22.6 m and the diameter at breast height to be 1.3 m when measured at 25.8 cm (Wang, Liu, Mo, Wang, Makeshin, & Wolff, 2010). This plantation was planted in 1983, and the data published in 2010 (Wang et al.). The stems are glabrous and have a jointed appearance with distinct nodes, this is due to the stipule encircling the stem (Bogle, 1991; Flora of China, n.d.). *Mytilaria* is unistipulate, this characteristic is common in the closely related genus, *Exbucklandia*, and both are recognized as being in the subfamily Exbucklandioideae (Bogle, 1991; Li, Bogle, & Klein 1999). Although both *Exbucklandia* and *Mytilaria* are unistipulate, they differ in their nodal anatomy; *Mytilaria* being multilacunar, and *Exbucklandia* being trilacunar (Bogle, 1991). The stipule is tubular and encloses the apical bud (Flora of China, n.d.).

*Mytilaria* has a larger leaf than *Exbucklandia*, it is 10-13 cm long and 7-10 cm wide (Huang et al., 2017; Lecomte 1924). The leaf is broadly ovate and almost always three-lobed or tricuspidate (Wu et al., 2009; Huang et al., 2017; Flora of China, n.d.). The leaf base is cordate and described as “peltate eccentric” by Huang et al. (2017). Photographs observed of *M. laosensis* clearly demonstrate this almost peltate attachment, but the petiole attaches more towards the lower half of the leaf instead of the central point, much like *Menispermum* (Chen, Zeng Jia, Zeng, Guo, & Cai, 2012; Krussman, 1984). The leaf margin is consistently entire (Flora of China, n.d.). The leaf

has actinodromous venation and is consistently palmately compound with five veins (Flora of China, n.d.; Lecomte, 1924). The apex is acuminate, and has a drip-tip much like *Exbucklandia* (Huang et al., 2017). Adaxially the leaf is shiny and drying to olive green, and adaxially it is yellow-green or gray (Lecomte, 1924). *M. laosensis* has a very long petiole, 7-10 cm (Flora of China, n.d.).

The flowers of *M. laosensis* are white and occur on spicate inflorescence which is held terminally or positioned opposite to leaf attachment (Flora of China, n.d.; Bogle, 1991). *Mytilaria* has more flowers per inflorescence than *Chunia*, which also has a spicate inflorescence (Bogle, 1991). The flowers are usually 5-merous, with petals that are linear or liguliform, consistent with a main characteristic of the Hamamelidaceae (Flora of China, n.d.). There are usually five sepals per flower, and each sepal is ovate to rounded (Flora of China, n.d.). Flowers are bisexual, the ovary is semi-inferior, and ovules are held six per locule (Flora of China, n.d.). The sunken ovaries of *Mytilaria* occur also in *Chunia*, but are unique to just these genera in the Hamamelidaceae (Bogle, 1991). The stamen number is described in some sources as uncertain, but the Flora of China states that *M. laosensis* has 10-13 stamens with short filaments. Flowering period is March to June, and fruiting period is July to September (Lecomte, 1924). Yellowish capsules are dehiscent and two-valved, ovoid to globose, with brown ellipsoid seeds that have a thick coat (Flora of China, n.d.; Lecomte, 1924).

*M. laosensis* is native to tropical and subtropical broad-leaved evergreen forests in Laos, north Vietnam, and three provinces in China (Liu et al., 2017; Chen et al., 2012; Ming et al., 2014). It is not listed by the IUCN Red List (IUCN Red List,



2018). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 50 *Mytilaria laosensis*: BGCI Institution Report and BGCI Collections Survey

<i>Mytilaria laosensis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	1
Countries	1	1
Accessions	N/A	2
Wild Provenance	N/A	0
Plants	N/A	2

## 2.18 *Neostrearia* Overview

**Nomenclature and Taxonomy:** Although *The Plant List 1.1* lists *Neostrearia* as unresolved, a review of the literature supports this genus being treated as accepted. Sources that recognize *Neostrearia* include Li, and Bogle (2001), Endress (1989), and Raven, and Axelrod (1974). *Neostrearia* is in the subtribe Dicoryphinae, and like all members of this subtribe, is native to the southern hemisphere (Li, & Bogle, 2001). It is closely related to *Ostrearia*, but the two genera are morphologically distinct (Li, & Philbrick, 1980; Raven, & Axelrod, 1974). *Neostrearia* is a monotypic genus (Raven, & Axelrod, 1974). There are no known cultivars of *Neostrearia*.

### 2.18.1 *Neostrearia fleckeri* L.S.Sm.

Original Publication: Proc. Roy. Soc. Queensland 69: 46. 1958

*Neostrearia* is a tree that grows to 12 m tall (Hewson, 1989). The leaves of *N. fleckeri* are simple, lanceolate or oblong-lanceolate, 18 cm long, and 7 cm wide

(Hewson, 1989). The petiole is 3-12 mm long, stipules are “bristle-like” and up to 4 mm long (Hewson, 1989).

The inflorescence is a spike that holds numerous flowers, with a 3.5 cm long peduncle, and a 10 cm long rachis (Hewson, 1989). The long inflorescence is a feature that helps separate *Neostrearia* from *Maingaya* (Hewson, 1989). The inflorescence is subtended by bracts that are up to 2.5 mm long (Hewson, 1989). Sepals are fused into a tubular calyx that is 3.5 mm long, and the calyx ruptures at anthesis (Li, & Bogle, 2001; Hewson, 1989). Petals are white, strap-like, 1-1.3 cm long, 1.5-2 mm wide, and are coiled in bud (Li, & Bogle, 2001). Styles are 0.2 mm long and are diagnostically shorter than the stamens which are ca. 1.5 mm long (Li, & Bogle, 2001; Hewson, 1989). Staminodes are lacking, which helps distinguish *Neostrearia* from *Embolanthera* (Hewson, 1989). The ovary is bicarpellate with more than one seed per locule (Li, & Bogle, 2001). The anther thecae are paired but open by just one valve, this is diagnostic for several members of the family including *Noahdendron*, *Ostrearia*, *Dicoryphe*, and *Hamamelis* (Crane, 1989). The fruit is a capsule that is 1-1.5 cm long and holds a seed that is ca. 1 cm long (Hewson, 1989).

*N. fleckeri* is endemic to tropical rainforests in northeastern Queensland, Australia (Li, Bogle, & Klein, 1999). It is found along streams and in lowland rainforest habitats (Hewson, 1989). This species is not listed by the IUCN Red List, and there is no indication that is of conservation concern locally. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 51 *Neostrearia fleckeri*: BGCI Institution Report and BGCI Collections Survey

<i>Neostrearia fleckeri</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	2
Countries	1	2
Accessions	N/A	2
Wild Provenance	N/A	0
Plants	N/A	3

## 2.19 *Noahdendron* Overview

**Nomenclature and Taxonomy:** *Noahdendron* is listed as unresolved by *The Plant List 1.1*, but a review of the literature supports treating this genus as accepted. Sources that accept *Noahdendron* include; Magallón (2007), Li, and Bogle (2001), and Crane (1989). Endress published the genus name in 1985 and treated the genus as monotypic, represented by the species *N. nicholasii* (IPNI, 2005). The name *Noahdendron* is in reference to Noah Creek in the Cape Tribulation region, Australia where it is native (Tng, 2011). *Noahdendron* is in the subtribe Dicoryphinae within the subfamily, Hamamelidoideae (Li, Bogle, & Klein, 1999). Tng (2011) states that garden centers in Queensland that focus on native plants offer this taxon for sale. No cultivars are known of *Noahdendron*.

### 2.19.1 *Noahdendron nicholasii* P.K. Endress, B.Hyland & Tracey

Original Publication: Bot. Jahrb. Syst. 197(1-4): 372. 1985 (20 Dec 1985)

*N. nicholasii* is a tree that grows to 10 m (Hewson, 1989). The leaves are oblong or elliptic, with an acuminate apex and attenuate base (Hewson, 1989). The leaf is 30 cm long and 10 cm wide, which makes it one of the largest leaves in the

Hamamelidaceae (Hewson, 1989). The petiole is 0.8-1.5 cm long (Hewson, 1989). The presence of a large stipule is unusual for the Hamamelidoideae (Hewson, 1989). The stipules are basally attenuate, asymmetrically ovate, 2 cm long, and 1 cm wide (Hewson, 1989). New growth is red and described as “stunning” in the collection notes of an herbarium voucher (Ford, & Holmes BRI-AQ0495928, 2000).

The inflorescence is a densely flowered spike that is pendant (Hewson, 1989). The peduncle is 5 cm long, and the rachis is 7 cm long (Hewson, 1989). Bracts are present on both the inflorescence and individual flowers (Hewson, 1989). The inflorescence bracts are 1 cm long, and the floral bracts are just 4 mm long (Hewson, 1989). The sepals are described by Hewson (1989) as “ovate-triangular” and are 3 mm long with dense stellate pubescence. The petals are red to purple in color, 5 mm long, and glabrous (Hewson, 1989). Hewson states that the red stamens are ca. equal to the petal length, 5 mm, and that the styles are ca. 1 mm. This is consistent with Li, and Bogle (2001) stating that the styles are shorter than the stamens, which they state helps to distinguish *Noahdendron*. The stigma is capitate (Hewson, 1989). The ovary is bicarpellate with more than one seed per locule (Li, & Bogle, 2001). The anther thecae are paired but open by just one valve (Crane, 1989). The fruit is a capsule that is 1 cm long and 1 cm wide, and seeds are 7 mm in length (Hewson, 1989). Notes from an herbarium voucher of this taxon state that the fruit is “velvety brown outside, pinkish brown-cream inside” (Ford, & Holmes BRI-AQ0495928, 2000).

*Noahdendron* is endemic to Queensland, Australia (Li, & Bogle, 2001). With a range restricted to just Cape Tribulation (Hewson, 1989). It is found in rainforest habitats adjacent to streams at elevations ca. 100 m (Hewson, 1989). This species is not listed by the IUCN Red List, but listed as locally “Endangered” in Queensland

(Atlas of Living Australia, n.d.). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections. The only institution that reported *N. nicholasii* was the Cairns Botanic Garden in Australia.

[Table 52 *Noahdendron nicholasii*: BGCI Institution Report and BGCI Collections Survey

<i>Noahdendron nicholasii</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	1	1
Countries	1	1
Accessions	N/A	1
Wild Provenance	N/A	0
Plants	N/A	2

## 2.20 *Ostrearia* Overview

**Nomenclature and Taxonomy:** Although *The Plant List 1.1* presently lists *Ostrearia* as unresolved, a review of the literature supports it being treated as accepted for this thesis. Sources that support *Ostrearia* include; Hewson (1989), Li, and Bogle (2001), and Crane (1989). The genus name *Ostrearia* comes from the Latin word “ostrea”, meaning oyster, which is in reference to the similarity of the fruiting capsule to a bivalve (Hewson, 1989). *Ostrearia* is in the subtribe Dicoryphinae (Li, Bogle, & Klein, 1999). No cultivars of *Ostrearia* were found in the literature.

### **2.20.1 *Ostrearia australiana* Baill.**

Original Publication: Adansonia 10: 131, in obs. 1871; C. T. White in Proc. Roy. Soc. Queensl. 1935, xlvii. 61 (1936), descr. ampl.

*Ostrearia* is a tree that grows to 25 m (Hewson, 1989). The leaves are elliptic or lanceolate, 17 cm long, and 6 cm wide, and the petioles are 7-12 mm long (Hewson, 1989). Abaxially the leaves have distinct stellate hairs (Tng, 2010). The stipules are 7 mm long and lanceolate in shape, this helps distinguish *Ostrearia* from the spur-like stipules in *Neostrearia* (Hewson, 1989).

The inflorescence is a densely flowered spike with a 1 cm long peduncle and a 3 cm long rachis (Hewson, 1989). The inflorescence is subtended by bracts that are 2 mm long, and the bracteoles are up to 1.5 in length (Hewson, 1989). The calyx is lobed and 3 mm long (Hewson, 1989). The petals are 7-9 mm long, 1-1.5 mm wide, and they are pale-green or yellow-green in color (Hewson, 1989). Styles are ca. 3 mm long, and the stamens are ca. 2 mm (Hewson, 1989). This differs from an observation made by Li, and Bogle (2001) that states the styles are distinctly shorter than the stamens, as is the case with *Neostrearia*. The anther thecae are paired but open by just one valve (Crane, 1989). The fruit is a glabrescent capsule that is 1.2-1.7 cm long and 1.2-2.4 cm wide (Hewson, 1989). The capsule is adnate to the tubular calyx for 3-5 mm (Hewson, 1989). The seeds are ellipsoidal and 1-1.5 cm long (Hewson, 1989).

*O. australiana* is endemic to northeastern Australia and is the most commonly occurring member of the Hamamelidaceae in Australia (Li, & Bogle, 2001; Hewson, 1989). It is found in tropical rainforests adjacent to streams at elevations ca. 900 m (Hewson, 1989). This species is not listed by the IUCN Red List, and is listed locally as of “Least Concern” in Queensland (Atlas of Living Australia, n.d.). The table below shows a summary of the BGCi Institution Report and the BGCi Collections Survey

for this taxon in *ex situ* collections. The two institutions that reported this taxon were the Brisbane Botanic Gardens and the Royal Botanic Gardens Sydney, both in Australia.

[Table 53 *Ostrearia australiana*: BGCI Institution Report and BGCI Collections Survey

<i>Ostrearia australiana</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

## 2.21 *Parrotia* Overview

**Nomenclature and Taxonomy:** The genus *Parrotia* was named by Karl Anton Meyer in 1831 after collecting it in the Caucasus (Nicholsan, 1989). He named it in honor of a German plant collector, Friedrich Parrot, who was the first European to summit Mount Ararat in 1829 (Nicholsan, 1989). *Parrotia* is most closely related to *Fothergilla*, and *Parrotiopsis*, and is interfertile with the genus *Sycopsis* (Li, & Bogle, 2001; Li, Bogle, & Klein, 1999). *Parrotia* is part of the subtribe “Fothergillinae”, which includes the aforementioned genera, as well as *Distylium* and *Distyliopsis* (Li, Bogle, and Klein, 1999). Surprisingly, *The Plant List 1.1* lists only one accepted species, *P. subaequalis* (H.T. Chang) R.M. Hao et H.T. Wei, whereas most sources site *P. persica* (EC) C.A. Mey. as being accepted as well. There is enough support for both species to be recognized as valid, and they will be treated here as such.

**Description:** *Parrotia* spp. are deciduous trees with distinct exfoliating bark, and an alternate leaf arrangement (Adroit, Malekhosseini, Girard, Abedi, Rajaei, Terral, & Wappler, 2018). Leaves are obovate with toothed margins (Zhang, Shi, Yang, Geng, Qiu, & Wang, 2018). Flowers are apetalous, and believed to be wind pollinated (Li, & Del Tredici, 2008). The inflorescence is a head composed of 4-7 flowers with brown bracts at the base and occur in clusters (Li, & Del Tredici, 2008). Li, & Tredici (2008) state each flower has 5 sepals, whereas the Flora of China cites 7-8 per flower. The flowers are either male or bisexual with 10-15 stamens (Flora of China, n.d.). Fruit is a two-chambered woody capsule that are densely pubescent (Li, & Del Tredici, 2008; Flora of China, n.d.). Each chamber holds two brown seeds (Li, & Del Tredici, 2008). The capsules are sessile and are spirally arranged along the rachis (Flora of China, n.d.). Both species are cultivated in North America, Europe, and Asia (Zhang et al., 2018).

#### **2.21.1 *Parrotia subaequalis* (H.T. Chang) R.M. Hao et H.T. Wei**

Original Publication: Acta Phytox. Sin. 36(1): 80. 1998 (10 Jan 1998)

*Parrotia subaequalis* is commonly known as the Chinese Ironwood (Li, & Zhang, 2015). The first collection of this species occurred in 1935 in the Jaingsu province in China (Li, & Del Tredici, 2008). In 1960, Professor Ho Tseng Chang described this material as *Hamamelis subaequalis*. It was not until 1988 that it was collected again, and in the interim it was believed to be extinct (Li, & Del Tredici, 2008). A flowering population was located in 1991, and from this the characteristic apetalous of the material was observed (Li, & Del Tredici, 2008). This prompted Miaobin Deng to create a new genus *Shaniodendron* to accommodate this characteristic (Li, & Del Tredici, 2008). Another taxonomist, Dr. Riming Hao,



believed that this material was closely related to the *Parrotia persica*, and in 1996 Dr. Yinlong Qiu and Jinahua Li coordinated the comparison of DNA from *Shaniodendron subaquale* to other members of the family (Li, & Del Tredici, 2008). It is from this study that *S. subaequale* was finally recognized as *Parrotia subaequalis* (Li, & Del Tredici, 2008). *Parrotia subaequalis* is present, but uncommon in cultivation. Li, & Zhang describe it being used for bonsai in some parts of China (2015). The Royal Horticultural Society's Plant Finder lists four suppliers in the United Kingdom, and three online sources were located in the United States; Pleasant Run Nursery in New Jersey, Forest Farm at Pacifica in Oregon, and Broken Arrow Nursery in Connecticut.

*P. subaequalis* is a deciduous tree that grows to 8 m (Zhang et al., 2018). Young branches have stellate pubescence and become glabrous with age (Flora of China, n.d.). Leaves are broadly ovate to elliptic, 4-6.6 cm long, and 2-4.5 cm wide (Flora of China, n.d.). The base is rounded, truncate or subcordate, and the apex is obtuse (Flora of China, n.d.). There are 4-5 veins on each side of the midvein, and the veins are prominent abaxially (Flora of China, n.d.). The adaxial surface is green with hairs only on the veins (Flora of China, n.d.). Abaxially the leaves have stellate pubescence, with pale brown hairs (Flora of China, n.d.). The petioles are 5-7 mm long, and also have stellate pubescence (Flora of China, n.d.). Unlike *P. persica*, *P. subaequalis* has lanceolate stipules (Li, & Del Tredici, 2008).

Flowers are bisexual and occur in a capitate spiked inflorescence on a peduncle that is 1 cm long (Geng, Yao, Yang, He, Wang, Wang, & Lio, 2015, Flora of China n.d.). The first and second flowers at the base of this inflorescence are often male (Flora of China, n.d.). *P. subaequalis* differs from *P. persica* in that the sepals are connate, creating a "saucer-shaped" calyx (Li, & Del Tredici, 2008). Individual sepals

are ovate and 3 mm long (Flora of China, n.d.). The bracts are large and ovate, abaxially the bracts have thick brown pubescence, and adaxially they are almost glabrous (Flora of China, n.d.). The floral cup is indistinct, and the ovary is semi-inferior (Flora of China, n.d.) The styles are short, 2 mm long, and the stigmas are fused (Flora of China, n.d.). Stamens are 3-10 per flower, with short filaments, and oblong anthers that are 4-4.5 mm long (Flora of China, n.d.). The connectives are elongated (Flora of China, n.d.). The flowering period is May to June, and only occurs every two to three years (Flora of China, n.d.; Geng et al., 2015). Fruit is a subglobose woody capsule that is 8-9 mm wide, with two dehiscent valves (Flora of China, n.d.; Zhang et al., 2018). Seeds have both an acute base and apex, and are 6-7 mm long (Flora of China, n.d.). Fruiting period is June to August (Flora of China, n.d.).

*P. subaequalis* is endemic to China, with only five known populations in Jiangsu, Zhejiang, and Anhui provinces (Li, & Del Tredici, 2008). Of these five populations, only 100 mature individuals were counted. For their 2015 study, Li, & Zhang recorded 720 individuals within their test plots across eight sites. *P. subaequalis* is found on hillsides or canyons in mixed evergreen or deciduous forests between 200-1100 m elevations (Li, & Zhang, 2015; Zhang et al., 2018). The IUCN Red List recognizes this as the synonym *Shaniodendron subaequale* and categorizes it as “Critically Endangered” (Flora of China, n.d.). It is also listed as “Endangered” in the *China Red Data Book* and is on the list of *Rare and Endangered Plants in China* (Geng et al., 2015; Li, & Zhang, 2015). Geng et al. found that the genetic variability at an individual level is quite high, but at the population level it is relatively low (2015). Another natural issue that impacts conservation is the alternate-year fruiting characteristic (Li, & Del Tredici, 2008). Anthropogenic impacts on *P. subaequalis*

populations include habit disruption, competition from bamboo, tourism, and theft for bonsai (Li, & Del Tredici, 2008; Li, & Zhang, 2015). The table below shows a summary of the BGC I Institution Report and the BGC I Collections Survey for this taxon in *ex situ* collections.

[Table 54 *Parrotia subaequalis*: BGC I Institution Report and BGC I Collections Survey

<i>Parrotia subaequalis</i>	BGC I Institution Report	BGC I Collections Survey
Institutions	36	25
Countries	8	6
Accessions	N/A	45
Wild Provenance	N/A	3
Plants	N/A	51

### 2.21.2 *Parrotia persica* (DC) C.A. Mey

Original Publication: Verz. Pfl. Casp. Meer. (C.A. von Meyer). 46. 1831 (Nov-Dec 1831)

*Parrotia persica* is commonly called the Persian Ironwood, in reference to its strong wood an ancestral name of its native range (Chehalmardian, Farsi, Kiaei, Kord, & Moya, 2015). Although the wood is strong, it is not used for lumber, and is used for charcoal or firewood by indigenous people (Akbarian, Bruschi, Fayyaz, Sattarian, & Zarafshar, 2011). It was initially described as a species of *Hamamelis* in 1830 by Augustin de Condolle, but was deemed a unique genus just a year later, retaining the specific epithet “persica” (Nicholsan, 1989). Another species *P. siderodendron* C.A.

Mey ex Ledeb. is a synonym to *P. persica* (Hassler, 2019). Adroit et al. describe it as “the most emblematic and important plant species from Iran”, and with such accolades it is no surprise that it is found in cultivation in Asia, Europe, Australia, and North America (Adroit, Malekhosseini, Girard, Abedi, Rajaei, Terral, & Wappler, 2018). Less than ten years after its discovery, *P. persica* was reported as cultivated in Russia, in 1841 Kew Gardens recorded receipt of this species, and by 1880 the Arnold Arboretum had added it to their collection (Nicholsan, 1989).

*P. persica* withstands a variety of environmental conditions that make it suitable for use as a street tree, and its fall coloring and upright habit are desirable in residential sites (Philips, 2014). In 1941, The Arnold Arboretum list just one commercial supplier of *P. persica* in San Jose, California (Arnoldia, 1941). Philips (2014) states that it is available commercially from most nurseries. The RHS Plant Finder listed 42 suppliers in the United Kingdoms, and a quick online search yielded over a dozen suppliers in the United States. The BGCI Collections Survey reported 757 individual plants from 61 institutions, and 28 of these accessions are of wild origin.

*P. persica* is a deciduous multi-stemmed specimen tree that grows to 12 m tall, and 5-9 m wide (Chehalmardian et al., 2015; Philips, 2014). Chehalmardian et al. (2015) describe it as being “low-branched” and from personal observations of living specimens this characteristic holds true. The bark is flat gray that flakes to reveal tan to green splotches of inner bark (Yosefzadeh, Tabaria, Akbarinia, Akbarian, & Bussotti, 2010). The flaking bark adds interest to the winter landscape.

New growth is attractive, red to purple in color and maturing to dark green (Yosefzadeh et al., 2010). Leaves are 8-10 cm long and 6 cm wide with a wavy or

toothed margin (Nicholsan, 1989; Adroit et al., 2018). The base is asymmetrical, and the apex is rounded, tapering to a blunt point (Nicholsan, 1989; Adroit et al., 2018). Petioles are 1 cm long (Adroit et al., 2018). Fall color is very ornamental, described as scarlet, maroon, orange, yellow and pink (Nicholsan, 1989) but extremely variable. Flowers are apetalous, have brown pubescent bracts, and red stamens that are densely clustered (Nicholsan, 1989). The flowering period is from March to April (Philips, 2014).

Its native range extends through Azerbaijan, Uzbekistan, and the Hyrcanian forests in Iran (Hassler, 2019; Chehalmardian et al., 2015). Nicholsan describes it is growing “in a limited area of the southeastern Caucasus mountains” (1989). One source states that there are just three native stands, but that *P. persica* is either the dominant species or co-dominant with *Fagus orientalis* and *Carpinus betulus* (Sefidi, Behjou, Copenheaver, & Kakavand, 2015). *P. persica* is found at elevations of 150-700 m, and tolerates drought, heat, wind, and cold being hardy to USDA zone 4 (Sefidi et al., 2015; Dirr, 1998; Philips, 2014). In garden settings, it does well in full sun, and tolerates most soil types (Philips, 2014). Although not listed as being of conservation concern, the restricted range and human impact are of some concern for the continued health of wild populations (Sefidi et al., 2015). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 55 *Parrotia persica*: BGCI Institution Report and BGCI Collections Survey

<i>Parrotia persica</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	333	63

Countries	28	14
Accessions	N/A	425
Wild Provenance	N/A	15
Plants	N/A	859

### 2.21.3 *Parrotia* Cultivars

Approximately 30 unique cultivar names were found in the literature. Only *P. persica* has named cultivars. Cultivars were selected for overall form, smaller habit, variegation, and more intense coloration of new growth or fall foliage. The BGCI Collections Survey did provide support for some of these names. Below is a list of the cultivar names located in the literature. Additional details for each cultivar can be found in Appendix A.

*Parrotia persica* ‘Alata’

*Parrotia persica* ‘Bella’

*Parrotia persica* ‘Biltmore’

*Parrotia persica* ‘Burgundy’

*Parrotia persica* ‘Chrishaven 1’

*Parrotia persica* ‘Cobhay Upright’

*Parrotia persica* ‘Fastigiata’

*Parrotia persica* ‘Felicie’

*Parrotia persica* ‘Globosa’

*Parrotia persica* ‘Henny’s Dwarf’

*Parrotia persica* ‘Henry’s Compact’

*Parrotia persica* ‘Het Plantsoen’

*Parrotia persica* ‘Horizontalis’

*Parrotia persica* 'Inge's Ruby Vase'  
*Parrotia persica* 'Jennifer Teates'  
*Parrotia persica* 'JLColumnar'  
*Parrotia persica* 'Jlpn01'  
*Parrotia persica* 'Jodrell Bank'  
*Parrotia persica* 'Jodrell Bank'  
*Parrotia persica* 'Kews Weeping'  
*Parrotia persica* 'Lamplighter'  
*Parrotia persica* 'Mikinori Ogisu'  
*Parrotia persica* 'Pendula'  
*Parrotia persica* 'Persian Carpet'  
*Parrotia persica* 'Persian Lace'  
*Parrotia persica* 'Persian Spire'  
*Parrotia persica* 'Prostrata'  
*Parrotia persica* 'Purpleleaf Form'  
*Parrotia persica* 'Red Bull'  
*Parrotia persica* 'Red October'  
*Parrotia persica* 'Ruby Vase'  
*Parrotia persica* 'Select'  
*Parrotia persica* 'Summer Bronze'  
*Parrotia persica* 'Vanessa'  
*Parrotia persica* 'Variegata'  
*Parrotia persica* fastigiata  
*Parrotia persica* New Zealand Form

## 2.22 *Parrotiopsis* Overview

**Nomenclature and Taxonomy:** The Greek term “opsis”, meaning likeness to, is used as the suffix due to the likeness of *Parrotiopsis* to *Parrotia* (Rehder, 1990). Indeed, *Parrotiopsis* is most closely related to *Parrotia* and *Fothergilla* (Li, & Bogle, 2001). Rehder states that *Parrotiopsis* differs from *Parrotia* most notably in its leaf characteristics, *Parrotiopsis* having leaves more like *Alnus glutinosa* (1990). *Parrotiopsis* also has more stamens than *Parrotia*, and obtuse valvate anthers with upright filaments (Flora of Pakistan, n.d.). The genus was first described as a species of *Fothergilla*, *F. involucrata*, when it was first discovered by Scottish botanist, Hugh Falconer, in 1836 (Wott, 2017). But in 1905 the German botanist, Camillo Karl Schneider published this plant material under the new name *Parrotiopsis involucrata* (Weaver, 1976; IPNI, n.d.). Although *The Plant List 1.1* does recognize *P. involucrata* as being an accepted name, most sources only recognize *P. jacquemontiana* (Decne) Rehd. as valid with both *F. involucrata* and *P. involucrata* presently recognized as synonyms (Ali, Khan, Sajid, & Zahra, 2018). There are no known cultivars of *Parrotiopsis*.

### 2.22.1 *Parrotiopsis jacquemontiana* (Decne) Rehder

Original Publication: Journal of the Arnold Arboretum. 1: 256. 1920

As *P. jacquemontiana* has many uses in its native range in Pakistan, it has acquired many common names including “beranj”, “hatab”, and “pohu” (Ali, Khan, & Sajid, 2017; Landscape Plants, n.d.). *P. jacquemontiana* is valued for its topical antiseptic qualities, much like *Hamamelis*, and the wood and stems are used for walking sticks, tool handles, and baskets (Ali et al., 2017; Flora of Pakistan, n.d.). Plant material was first introduced into cultivation in 1879 in Kew Gardens in London



(Wott, 2017). Kew gifted *P. jacquemontiana* to the Arnold Arboretum in 1910, and this is the first record of it in the United States (Weaver, 1976). At the time of his writing in 1976, Weaver states that *P. jacquemontiana* is not commercially available in the United States. The 2017 publication by Wott states that this species is rare in cultivation, and only five suppliers were listed by the Royal Horticultural Society as selling *P. jacquemontiana*. However, the BGCI Collections Survey reports 104 plants in global living collections representing 68 accessions. So it is at least has some presence in collections globally.

*P. jacquemontiana* is a deciduous shrub or small tree that grows to 5 m (Ali et al., 2018). Branches are strong, flexible, and covered in hairs (Plants for a Future, n.d.; Wott, 2017). The mature bark is smooth and gray (Wott, 2017). Buds are stalked and covered with two scales that are sparsely tomentose (Rehder, 1990). Leaf arrangement is alternate (Landscape Plants, n.d.). Leaves are sub-orbicular, 5-8 cm long with a crenate to serrate margin (Flora of Pakistan, n.d.; Rehder, 1990). No description of the leaf base was located, but a digitized specimen was observed to have an asymmetric and truncate base with part of the leaf extending onto the petiole creating a narrow margin on either side of the petiole (Hu 03827436, 1988). Adaxially leaves are shiny, and abaxially leaves are pubescent (Wott, 2017). Petioles are 6-12 mm and densely stellate to tomentose (Rehder, 1990). Oval stipules are present, but no information obtained on the placement or size (Rehder, 1990). Wott (2017) state that fall color “can be a bright yellow”, but both Dirr (1998) and Weaver (1976) state outright that it is not ornamental.

Flowers are bisexual and apetalous (Flora of Pakistan, n.d.). Gapinski states that *P. jacquemontiana* represents an intermediate stage in the loss of petals within the

family, and is “likely both insect and wind pollinated” (2015). Showy white bracts are 3-5 cm across and have purple-brown tomentum on the back (Rehder, 1990). Flowers form a dense head-like inflorescence that occurs on a short peduncle (Wott, 2017). Sepals are small, bell-shaped, pubescent, and occur in groups of 5 to 7 per flower (Rehder, 1990). Stamens are prominent and yellow, each flower having 15 stamens (Flora of Pakistan, n.d.; Wott, 2017). Filaments are slender and 3-4 mm long, and the yellow anthers are oval and dehisce by two-valves (Flora of Pakistan, n.d.; Rehder, 1990). The pubescent ovary is bilocular with two slender styles and a linear stigma (Flora of Pakistan, n.d.; Rehder, 1990). Flowering period is listed as March to May by the *Flora of Pakistan*, and April to June by *Plants for a Future*, and Wott (2017) states that after the initial flowering period intermittent summer flowering does occur. Fruit is an ovoid capsule that is clustered into heads (Rehder, 1990). The seed is shiny brown, elliptic, and 6 mm long (Flora of Pakistan, n.d.). It is noted the seeds are very slow to germinate, some sources siting 18 months to germinate (Plant for a Future, n.d.).

*P. jacquemontiana* is native to Afghanistan, and Upper Dir district in Pakistan (Flora of Pakistan, n.d.; Ali et al., 2017). *P. jacquemontiana* occurs as a dominant species in its native range, forming *Picea-Parrotiopsis* communities at 1,200-2,650 m elevations (Rahmen, Khan, Khan, Hussain, Rahman, Iqbal, & Ijaz, 2016). It is abundant on north-facing slopes and can create entire stands within the understory (Plants for the Future, n.d.). *P. jacquemontiana* is suitable for garden settings that are in part shade to full sun, with moist soil, and within USDA zones 6 to 9 (Plants for a Future, n.d.). Although the Flora of Pakistan and Ali et al. (2017) state that it is commonly distributed in five districts of Pakistan, Rahman et al. state that it is a

“rarely occurring endemic species” (2016). *Parrotiopsis* is not listed on the IUCN Red List. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 56 *Parrotiopsis jacquemontiana*: BGCI Institution Report and BGCI Collections Survey

<i>Parrotiopsis jacquemontiana</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	87	31
Countries	20	13
Accessions	N/A	68
Wild Provenance	N/A	8
Plants	N/A	104

### 2.23 *Rhodoleia* Overview

**Nomenclature and Taxonomy:** The genus *Rhodoleia* was first published in 1850 by John George Champion (Flora of China, n.d.; Bailey, 1949). *Rhodoleia* means “smooth rose” in Latin (Nurseries Caroliniana, n.d.). Although the leaves on *Rhodoleia* are strikingly different than *Exbucklandia*, the two genera are closely related (Gu, Luo, Zhang, & Renner, 2010). In a 1999 publication, *Exbucklandia* and *Rhodoleia* were assigned to the same clade within the Hamamelidaceae (Li, Bogle, & Klein, 1999). In 2007, *Rhodoleia* was assigned to its own subfamily the Rhodoleioideae, and *Exbucklandia* moved to a new subfamily, the Exbucklandioideae, which includes *Chunia* (Magallón, 2007). In 1933, Arthur Wallace Exell described seven species within the genus, but in 1957 Willem Vink described *Rhodoleia* as

monospecific and highly polymorphic (Suddee, & Middletown, 2003). In 1993, Peter K. Endress expressed the need for revision of *Rhodoleia* (Suddee, & Middletown, 2003). After the Bogle publication in 1999 and publication of the *Flora of China*, there are presently six species recognized; *R. stenopetala*, *R. forrestii*, *R. macrocarpa*, *R. championii*, *R. parvipetala*, and *R. henryi*. It is not uncommon for sources to list ten species in the genus, but the additional species listed are considered synonyms of *R. championii* (Flora of China, n.d.; Gu et al., 2010; Catalogue of Life, 2015).

*Rhodoleia* is native to Java, China, Vietnam, Thailand, Myanmar, Malaysia, Sumatra, and Indonesia (“Catalogue of Life”, 2015). In the fossil records, *Rhodoleia* emerged during or just before the Paleocene and could once be found across Europe (Gu et al., 2010). It is believed the genus originated in Europe and has since migrated to east Asia (Gu et al., 2010). Like its close relative *Exbucklandia*, *Rhodoleia* is also used in paleo botanical research.

Some species of *Rhodoleia* can be found in cultivation, and are available in the trade, but it is still considered uncommon in North American and European gardens. The cultivated species include *R. championii* and *R. henryi*. Crûg Farm Plants lists *R. parvipetala* for sale in the United Kingdom (Crûg Farm Plants, n.d.). Only one species of *Rhodoleia* is listed by the IUCN Red List. *Rhodoleia championii* is listed as of Least Concern (IUCN Red List, 2018).

**Description:** All species of *Rhodoleia* are evergreen trees or shrubs, with an alternate leaf arrangement (Flora of China, n.d.). This leaf arrangement can sometimes appear as pseudo-whorled at branch tips giving the plant an almost *Rhododendron* appearance. Three characteristics of *Rhodoleia* are unusual for the Hamamelidaceae; the leaves, stipules, and flowers. The leaves are unusual in that they are simple, ovate

to lanceolate with entire margins and pinnate venation. Another unusual characteristic for the family is that stipules appear to be absent. Peter K. Endress presented research, discussed in more detail below, to show the ephemeral presence of stipules in *Rhodoleia* (1978). Finally, the petals of *Rhodoleia* are not “strap-like” in shape, but are spatulate to oblanceolate. Each flower has zero to four petals as only those on the outer margin of the flower head develop (Suddee, & Middletown, 2003). In addition, the flowers occur in large, dense, capitate inflorescence with 4-6 flowers per inflorescence (Gu et al., 2010; Flora of China, n.d.). The pink-red inflorescences are axillary and nodding, often partially obscured by the evergreen leaves (Flora of China, n.d.; Gu et al., 2010). The flower is bisexual and described as scentless by Gu et al., but some retailers offering *Rhodoleia* state that it does have a scent (Gu et al., 2010; Crûg Plant Farms, n.d.). Gu et al. researched the pollination mechanisms of *Rhodoleia*, so their observation that it is scentless is one that is better supported (2010). Reviewing herbarium vouchers of this genus quickly highlights the obvious rounded bracts that enclose the base of the flowers (Flora of China, n.d.). Pubescence varies on the involucre bracts as well as the shape, but in each they are distinct (Flora of China, n.d.). The floral cup on all *Rhodoleia* is very short and encloses the base of the ovary (Flora of China, n.d.). *Rhodoleia* has two valved dehiscent capsules, and flat seeds (Flora of China, n.d.). Sterile seeds are wingless, and fertile seeds have a narrow, lateral wing (Flora of China, n.d.).

### **2.23.1 *Rhodoleia championii* Hook. f.**

Original Publication: Hooker, Bot. Mag. 76: t. 4509. 1850.

The Flora of China states the common name for *R. championii* as being “红花荷” or “hong hua he” (Flora of China, n.d.). Additional common names are the Hong

Kong Rose, King of Hanging Bells, and the Silk Rose (“Plants of Asia”, n.d.). *R. championii* has absorbed most of the unaccepted species names in this genus as synonyms. These synonyms include; *R. formosa* Champ. ex Hance (1852), *R. latiovatifolia* G.A. Fu (1991), *R. ovalifolia* Ridl. (1917), *R. subcordata* Exell (1933), and *R. teysmannii* Miq. (1857) (“Catalogue of Life”, 2015). As the oldest published name in the genus, it common to find vouchers of *Rhodoleia* first identified as *R. championii* and later renamed as another specific epithet.

*R. championii* is the most common species in the genus in cultivation, but still is unusual to find in garden settings. A 1986 publication states that *R. championii* was grown in Australia “some years back”, but at the time of that writing was hard to find (“*Rhodoleia championii*”, 1986). In China, a study from 2005 and 2006 described over 200 individuals of *R. championii* used in horticultural settings (Gu, Luo, Zhang, & Renner, 2010). This species can be used as timber for indoor construction, but does not appear to be a major timber crop in China (Vink, 1957). In the United Kingdom and Germany, seed is offered for sale from Crûg Farm Plants and Sunshine Seeds, respectively (Crûg Farm Plants, n.d.; Sunshine Seeds, n.d.). The Crûg Farm Plants’ seed is from a collection from Hoang Lien Mountain Range in north Vietnam (Crûg Farm Plants, n.d.). This expedition was in the fall of 2011 (Crûg Farm Plants, n.d.). In the United States, Woodlanders, Inc. of Aikens, South Carolina offers *R. championii* plants for sale (“Woodlanders, Inc”, n.d.). Their website states that it is “rare in cultivation in the U.S.” and that the stock for this plant is originally from the University of Florida in Gainesville, Florida (“Woodlanders, Inc”, n.d.).

*R. championii* is an evergreen tree or shrub with a *Rhododendron*-like habit (“*Rhodoleia championii*”, 1986). There is great discrepancy in the literature as to the

height of the plant. The Flora of China states that it grows to 12 m, a 1956 publication sites this as a monospecific genus growing to 25 m (Vink, 1956), and a 2003 paper on discovering the genus in Thailand states that it is 40 m tall (Flora of China, n.d.; Suddee, & Middletown, 2003). The Suddee and Middletown publication does cite *Rhodoleia* as being monospecific, based off of Willem Vink's work in 1956. Upon initial investigation, it could be thought that they are citing another species with this larger height, but none of the literature examined outside of Suddee and Middletown's publication lists a *Rhodoleia* as reaching 40 m in height. A Harvard University Herbarium specimen collected in Yunnan, China sometime between 1896 and 1899 was listed as growing to "40 feet" (Henry 00043466, 1896-1899). Perhaps there was an error in unit transcription from the time of voucher collection in 1956 and the Suddee and Middletown publication in 2003. In the United States, Woodlanders, Inc describes *R. championii* as growing 10-20' in height, and 10-12' wide ("Woodlanders, Inc", n.d.). This difference in height is most likely attributed to the garden setting and climate differences of the United States and *R. championii*'s native range in China and Thailand (Flora of China, n.d.).

Young branches are stout and glabrous (Flora of China, n.d.). The bark is a rusty-brown with "large pale lenticels", and the inner bark is salmon colored (Suddee, & Middletown, 2003). The evergreen leaves are leathery and create pseudo-whorls at branch tips ("*Rhodoleia championii*", 1986). The Flora of China describes the leaf as broadly ovate, 7-16 cm long, 4.5-10.5 cm wide, the base as broadly cuneate, and the apex obtuse to subacute (Flora of China, n.d.). An herbarium specimen collected in Vietnam has consistent acute leaf bases and small narrow leaves (No Collector 02913530, 1930). The largest leaf on this voucher is approximately 8 cm long and 3

cm wide, much smaller than the Flora of China's description (No Collector 02913530, 1930). Two other herbarium specimens examined had leaves more typical to the Flora of China's description, and the voucher from Harvard University Herbarium had superbly preserved flowers (Harris 01515457, 1902; Champion 00043467, 1849). An additional voucher from the Royal Botanic Gardens, Kew had unique sub-truncate leaf bases on most leaves in the voucher, this was not seen on any other vouchers examined (Ridley K000501081, 1911).

The Flora of China describes the venation as “obscurely three veined at base” (Flora of China, n.d.). There are seven to nine lateral veins on each side that are 60 degrees to the mid rib (Flora of China, n.d.). As with other species, reticulate venation is present, but in *R. championii* it is obscure, even on preserved specimens (Flora of China, n.d.). Adaxially the leaves are dark green, thick, and glossy (Suddee, & Middletown, 2003; Crûg Farm Plants, n.d.). Abaxially the leaves are bluish-white and usually glabrous, sometimes brown, stellate scales are present (“*Rhodoleia championii*”, 1986; Flora of China, n.d.). Petioles are 3-5.5 cm and red in color (Flora of China, n.d.; Suddee, & Middletown, 2003). Until Peter K Endress' publication in 1978, stipules were believed to be absent in *Rhodoleia*. Endress describes that “very conspicuous stipules were found to be present, but are restricted to a few leaves of the transition region between the bud scales and the foliage leaves” (Endress, 1978).

The nodding flowers are often hidden behind the evergreen leaves, but still possess ornamental value (*Rhodoleia championii*, 1986). The flower color is described along a spectrum of pink to red; pink, pink to purplish-red, rosy pink, bright pink to red, and bright red (*Rhodoleia championii*, 1986; Gu, Luo, Zhang, & Renner, 2010; Ridley K000501089, 1911; Crûg Farm Plants, n.d.; Suddee, & Middletown, 2003).



Narrow, spatulate petals 25-35 mm long and 4-8 mm wide are fused at the base to create bell-like heads (*Rhodoleia championii*, 1986; Flora of China, n.d.). These flowers are grouped four to six per inflorescence, the inflorescence is 3-4 cm wide, and is covered at the base by overlapping bracts (Gu et al., 2010; “*Rhodoleia championii*, 1986; Flora of China, n.d.). The bracts are tan and pubescent and each bract is ovate to rounded (Gu et al., 2010; Flora of China, n.d.). Five to six scale-like bracteoles are also at the base of each inflorescence (Flora of China, n.d.).

Individual flowers open before noon, but flowering period is not consistent in the literature (Gu et al., 2010). Gu et al. describe flowering period as late December to early March in its native range in China, Crûg Farm Plants state that it blooms in mid to late summer in Vietnam and spring in cultivation, and Vink states the flowering period is June to January (Gu et al., 2010; Crûg Farm Plants, n.d.; Vink, 1956). The collection notes from the type specimen at Kew collected in July 1905 state that flowers are “rosy pink”, and the specimen appears to have recently flowered, as no petals were on the voucher (Wray, & Robison K000501081, 1905). As Vink treats *Rhodoleia* as a monospecific genus, the flowering period observed could be a range of all six species described in this paper (1957). Perhaps the flowering period differences are due to the difference in geographic locations that the specimens were observed.

The flowers are pollinated by birds, with wasps and bees playing a minimal role (Gu, et al., 2010). It is believed that the thick pedicels and peduncles evolved as a response to the aggressive pecking of birds (Gu et al., 2010). The peduncle is 2-3.8 cm long and has several scale-like bracts (Flora of China, n.d.). The type specimen from Kew demonstrates the thick and long peduncles clearly (Ridley K000961826, 1911). Interestingly, *Rhodoleia* emerged as late as the Paleocene in Europe, prior to the

emergence of birds that foraged for floral nectar (Gu et al., 2010). The mechanisms for pollination of *Rhodoleia* and response to its movement to east Asia was researched by Gu et al. in 2010. Pollination mechanisms are an important area of research for this species as *R. championii* is self-incompatible (Gu et al., 2010). Despite this, fruit set in wild populations is still high (Gu et al., 2010).

The infructescence is 2.5-3.5 cm wide, and typically has five capsules with flattened yellow-brown seeds (Flora of China, n.d.). Fruiting period is May to August, and a voucher with seed from Kew supports this, having been collected in July of 1911 (Flora of China, n.d.; Ridley K000961826, 1911).

*R. championii* is native to southeast Asia and the Asian tropics (*Rhodoleia championii*, 1986). More specifically, the native range is supported as being; four provinces in southeast China (Guangdong, Hong Kong, Guizhou, and Hainan), Indonesia, Malaysia, Myanmar, Vietnam, and Thailand (Flora of China, n.d.; Gu et al., 2010; Suddee and Middletown, 2003). The Flora of China states that “records of *Rhodoleia championii* from outside China must be treated with caution”. This is an interesting observation as all of the type specimens located for this thesis were collected in Malaysia (Flora of China, n.d., Wray, & Robinson K000501081, 1905; Ridley K000501089, 1911). In addition, Suddee and Middletown state that “the specific description has been drawn from Malaysian materials” (2003). Again, Suddee and Middletown only recognize one species of *Rhodoleia*, but their definition does correspond to the type specimen. The discrepancies in leaf morphology and flowering period, might be explained by some of these differences in provenance of observation and collected material.

The native habitat is described as broad-leaved evergreen forests in moist mountain regions at 700-1,000 m (“*Rhodoleia championii*”, 1986; Gu et al., 2010). *R. championii* grows in sun to part shade in humus rich well-drained soils (“Woodlanders, Inc”, n.d.; Crûg Farm Plants, n.d.). It can be frost tender, but plants collected at higher altitudes are reported to be hardier. Crûg Farm Plants recommends growing it in a “sheltered warm position”, and also states *R. championii* has survived temperatures as low as  $-15^{\circ}$  C. *R. championii* is listed as being of “Least Concern” by the IUCN Red List (IUCN Red List, 1998). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 57 *Rhodoleia championii*: BGCI Institution Report and BGCI Collections Survey

<i>Rhodoleia championii</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	15	4
Countries	8	2
Accessions	N/A	9
Wild Provenance	N/A	1
Plants	N/A	12

### 2.23.2 *Rhodoleia forrestii* Chun ex Exell

Original Publication: Chun ex Exell, Sunyatsenia. 1: 97. 1933.

The *Flora of China* lists the common name for *R. forrestii* as “绒毛红花荷” or “rong mao hong hua he” (n.d.). Previously, *R. forrestii* was listed as a variety of *R. championii* (“Catalogue of Life”, 2015). There is no indication in the literature that *R.*

*forrestii* occurs in cultivation. *R. forrestii* is a tree that grows to 15 m, and has elongated tomentose stems (Flora of China, n.d.). As with *R. stenopetala*, herbarium vouchers were used as a main source of information outside of the Flora of China for *R. forrestii*. New York Botanical Garden's Steere Herbarium had three useful specimens from 1938 to 1939, and Harvard University Herbaria and Library had one specimen from 1924-1925. Although leaf arrangement is indeed alternate, the branching on one preserved specimen of *R. forrestii* at the Steere Herbarium demonstrated the pseudo-whorls at branch tips for which the genus is known (Kingdon-Ward 02649929, 1939).

Leaves are oblong to lanceolate, 7-15 cm in length, and 2-7 cm in width (Flora of China, n.d.). The base is cuneate, and apex acute to acuminate (Flora of China, n.d.). Leaves have seven to nine lateral veins on each side at 45-degree angles to the mid rib. Adaxially the veins are sunken, this is very distinct on one specimen from the Steere Herbarium (Flora of China, n.d.; Kingdon-Ward 02649931, 1938). Abaxially the leaves are whitish-gray with brown tomentose or pillose pubescence (Flora of China, n.d.). The brown pubescence helps distinguish *R. forrestii* from the other species in this genus (Flora of China, n.d.). The herbarium specimen from the Harvard University Herbarium has clear tomentose hairs abaxially along the midvein (Forrest 00043470, 1924-1925). The petioles are rusty-brown and tomentose (Flora of China, n.d.).

Flower color was noted on an herbarium voucher from 1938 as being "cherry crimson" (Kingdon-Ward 02649928, 1938). Petals are oblanceolate and 6 mm in width, double the longest petal length of *R. stenopetala* (Flora of China, n.d.). The inflorescence itself is 3 cm, the Harvard University Herbarium voucher has beautifully

preserved flowers that have even retained some of their coloration (Flora of China, n.d.; Forrest 00043470, 1924-1925). This voucher also clearly shows the characteristic tomentose involucre bracts present at the flower base on *R. forrestii* (1924-1925). The bracts are described as ovate to rounded and 5-10 mm (Flora of China, n.d.). Flowering time is March to May in the Flora of China, but a voucher collected in late December 1937 or early January of 1938 has clear flowers (“Kingdon-Ward 02649928, 1938).

The ovaries are glabrous, and noted to be “crimson” on the notes of a Steere Herbarium specimen (“Kingdon-Ward 02649928, 1938). The peduncle is 1 cm long, and appears thick and woody (Flora of China, n.d.; “Kingdon-Ward 02649928, 1938). *R. forrestii* has 2.5-3 cm wide capsules that are ovoid to globose (Flora of China, n.d.). The seeds are uniquely dark brown (*R. macrocarpa* also exhibiting darker seed color), but seeds are flattened and winged as in other species of this genus (Flora of China, n.d.). Both the two valved capsule and the flattened seed with wings are well represented on a voucher from the Steere Herbarium (Kingdon-Ward 02649930, 1938). Notes on another voucher from Steere Herbarium state that there are “about 6 (capsules) in a compact head persisting for 2 years” (Kingdon-Ward 02649931, 1938). The fruiting period is from June to September (Flora of China, n.d.).

The Flora of China lists *R. forrestii* as being native to West Yunnan, China and Northeast Myanmar (Flora of China, n.d.). Fang et al. show the native range in China as just a narrow strip in west Yunnan Province (2011). Most vouchers in collections at the Steere Herbarium and Harvard University Herbarium were collected in Myanmar. Habitats of *R. forrestii* were described as evergreen forests at 1,500-2,000 m, “open grass (and) bracken hillsides” at “4000 to 6000 feet”, and “fairly thick forest” (Flora of

China, n.d.; Kingdon-Ward 02649930, 1938; Kingdon-Ward 02649931, 1938). A note on a voucher from the Steere Herbarium stated that *R. forrestii* was “abundant” at the time of collection in 1938 (Kingdon-Ward 02649930, 1938). The IUCN Red List does not have this species listed as being of conservation concern (IUCN Red List, 2018). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 58 *Rhodoleia forrestii*: BGCI Institution Report and BGCI Collections Survey

<i>Rhodoleia forrestii</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	0
Countries	1	0
Accessions	N/A	0
Wild Provenance	N/A	0
Plants	N/A	0

### 2.23.3 *Rhodoleia henryi* Tong

Original Publication: Tong Bull. Dept. Biol. Sun Yatsen Univ. 2: 35. 1930.

The Flora of China lists the common name for *R. henryi* as “小脉红花荷” or “xiao mai hong hua he”. Other common names include evergreen rose hazel, and Henry’s *Rhodoleia* (“JC Raulston Arboretum”, n.d.; “Nurseries Caroliniana, Inc”, n.d.). The specific epithet is in honor of Augustine Henry, a plant collector who was born in 1857 (Nurseries Caroliniana, Inc, n.d.; Index of Botanists, n.d.). Many of the *Rhodoleia* vouchers referenced in this thesis were collected by Augustine Henry. *R. henryi* is uncommon, but present, in cultivation in the United States. Nurseries and

gardens that either sell or have listed *R. henryi* include: Nurseries Caroliniana, Inc, JC Raulston Arboretum, Lisa J. Miner's "Plantilus", Urban Earth in Seattle, Washington, and Rare Finds in Jackson, New Jersey, and Crûg Farm Plants in the United Kingdom offers material listed as *R. aff. henryi* for sale. One of these collections is from the mountains near Sapa in north Vietnam in 2006, and the other from Tý in north Vietnam near the Chinese border (Crûg Farm Plants, n.d.).

A type specimen from 1933 describes the source material as coming from a 50' (15 m) tree, and the Flora of China also states the habit of *R. henryi* is a tree and that it grows to 15 m (Henry 20149, 1933). Crûg Farm Plants describes its habit as that of a large shrub in the United Kingdom. Thick stems with large scars above the leaf axil were observed on the type specimen, it was unclear if the scars were from spent inflorescence (Henry 20149, 1933). One terminal bud was observed on this same specimen, it was rounded with distinct scales and 1 cm across (Henry 20149, 1933).

Leaves are evergreen with alternate arrangement (Flora of China, n.d.). The leaves were described as ovate to elliptic by Flora of China, 11 cm long and 3-6 cm wide. The type specimen also shows these characteristics (Henry 20149, 1933). The leaf base is described as broadly cuneate, and the apex acuminate (Flora of China, n.d.). The type specimen had bases that were more acute than cuneate, and the apex was more acute to obtuse (Henry 20149, 1933). Six lateral veins are at 30 degree angles on each side of the mid rib (Flora of China, n.d.). The adaxial side of the leaf dries to dark green and has sunken venation (Flora of China, n.d.). The abaxial side is glabrous, with raised venation and dries to a yellow-green (Flora of China, n.d.). These abaxial and adaxial characteristics were not obvious on the type specimen. The petioles on the type specimen appeared long compared to the leaf size, measuring 3-5

cm in length (Henry 20149, 1933). In the literature, the petioles are described as 5 cm in length as well (Flora of China, n.d.).

The flower color of *R. henryi* is described as “crimson” on the type specimen, and as “dark red” by Flora of China (Henry 20149, 1933; Flora of China, n.d.). Petals are 30 mm long and 6 mm wide (Flora of China, n.d.). The inflorescence is 3-3.5 cm across, and is composed of five individual flowers with petals only on the outer side of the inflorescence (Flora of China, n.d.). The flattened flowers present on the type specimen were 4 cm in width and length, and placed terminally (Henry 20149, 1933). Flowering time is described as March to May by both the Flora of China and Crûg Farm Plants. The ovaries are glabrous, stamens are in groups of 7-9, and stamens are as long as petals (Flora of China, n.d.). No literature was located describing the capsules, but it is assumed they are consistent with the genus.

*R. henryi* is native to evergreen forests at elevation of 2,000-2,450 m in southeast Yunnan Province in China (Flora of China, n.d.; Fang et al., 2011). The type specimen notes state that it was collected in the Feng Chen Lin Mountains in Yunnan, China at approximately 2,400 m (Henry 20149, 1933). It should be noted that all herbarium specimens examined for this thesis of *R. henryi* were collected by Augustine Henry under the collection number “10,131” and were distributed to the Harvard University Herbarium (00043468 isotype), New York Botanical Garden Steere Herbarium (356145 type, 356144 isotype), and the Royal Botanic Gardens, Kew (K000704903). *R. henryi* is not listed by the IUCN Red List (IUCN Red List, 2018). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.



[Table 59 *Rhodoleia henryi*: BGCI Institution Report and BGCI Collections Survey

<i>Rhodoleia henryi</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	12	3
Countries	3	2
Accessions	N/A	9
Wild Provenance	N/A	1
Plants	N/A	9

#### 2.23.4 *Rhodoleia macrocarpa* H.T. Chang

Original Publication: H. T. Chang, Acta Sci. Nat. Univ. Sunyatseni. 1963(4): 50. 1963.

The *Flora of China* lists the common name for *R. macrocarpa* as “大果红花荷” and “da guo hong hua ha” (*Flora of China*, n.d.). Of the six species, *R. macrocarpa* is the most recently published name that is still considered valid (*Flora of China*, n.d.). There is no indication in the literature that *R. macrocarpa* occurs in cultivated settings.

*R. macrocarpa* is an evergreen tree growing to 10 m (*Flora of China*, n.d.). Young branches dry to brown and are covered in small stellate scales (*Flora of China*, n.d.). No herbarium voucher was located to compare these traits, and the only source located for this paper that listed characteristics of *R. macrocarpa* was the *Flora of China*. Leaves are elliptic or narrowly elliptic, 7-11 cm long, and 3-6 cm wide (*Flora of China*, n.d.). The leaf base is broadly cuneate, and *R. macrocarpa* is the only species described as having a mucronate apex (*Flora of China*, n.d.). The leaf is three-veined, and not prominent abaxially or adaxially (*Flora of China*, n.d.). Reticulate venation is present with 8-9 lateral veins on each side of the mid rib (*Flora of China*, n.d.). These lateral veins are 75-degrees to the mid rib, and help to distinguish *R.*

*macrocarpa* from the other species (Flora of China, n.d.). Unlike other species in this genus the adaxial side of the leaf is not shiny, and although *R. macrocarpa* does have a lighter leaf back, it is stellately scaled making it distinct (Flora of China, n.d.). Similar to other species, the petioles are long compared to the leaf size and are 2.5-4 cm (Flora of China, n.d.).

As noted above, there are many characteristics that make *R. macrocarpa* distinct, including the larger capsule size as outlined below. One concerning factor for recognition of *R. macrocarpa* is that the Flora of China notes only that the “flowers not [were] seen” (Flora of China, n.d.). As recently as 1957, Willem Vink lumped all species treated here into one species *R. championii*, and the Suddee and Middletown paper in 2003 treated *Rhodoleia* as monospecific referencing Vink. Although Li et al. and the Flora of China have heeded Peter K. Endress’ prompt to reevaluate the Hamamelidaceae and *Rhodoleia*, it is still questionable if *R. macrocarpa* can truly stand on its own as a distinct species (Li, Bogle, & Klein, 1999). Even without observing the flowers, the Flora of China does list the petals as spatulate or oblanceolate, and that *R. macrocarpa* flowers from March to June (Flora of China, n.d.).

The fruiting structure is 2.5-3.5 cm wide, and contains five glabrous and ovoid capsules. Each capsule is 1.2-2 cm long and 0.6-1 cm wide (Flora of China, n.d.). Like *R. forrestii*, the seeds on *R. macrocarpa* are a dark brown color (Flora of China, n.d.). The fruiting period is from August to September (Flora of China, n.d.).

*R. macrocarpa* has a very limited range in southeast Yunnan, China (Fang, Wang, & Tang, 2011). It grows in evergreen forests at elevations of 2,000 to 4,000 m (Flora of China, n.d.). This species is not listed by the IUCN Red List (IUCN Red

List, 2018). Due to the lack of information available for this species, and the limited range that overlaps with other species in this genus, it is recommended that further research be done to create a more conclusive argument for or against *R. macrocarpa* as an accepted species. No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.23.5 *Rhodoleia parvipetala* K.Y. Tong**

Original Publication: Bull. Dept. Biol. Sun Yatsen Univ. 2: 35. 1930.

The Flora of China lists the common name for *R. parvipetala* as “小花红花荷” or “xiao hua hong hua he” (Flora of China, n.d.). Although not as common as *R. championii*, Crûg Farm Plants does presently sell 15 L plants from a 2007 collection on Sé Mí Tý, Vietnam (Crûg Farm Plants, n.d.). Previously, they had sold seed from another collection in 2007 from Vietnam near the Chinese border (Crûg Farm Plants, n.d.).

*Rhodoleia parvipetala* is an evergreen tree that grows to 20 m (Flora of China, n.d.). One herbarium voucher, an isotype from Yunnan, China, was noted as being from a specimen that was 40', or 12.2 m (Henry 00043466, 1896-1899). The age of this specimen is not known. Stems are stellately scaled, but “quickly glabrescent” according to the Flora of China. The leaf is oblong, 5-10 cm long, and 2-4 cm wide (Flora of China, n.d.). The margin is entire, the leaf base is cuneate, and the apex is acute (Flora of China, n.d.). The leaf shape and size described by the Flora of China are consistent with the isotype examined from the Harvard University Herbarium (Henry 00043466, 1896-1899). Like *R. championii*, *R. parvipetala* leaves are obscurely three veined and this is present mostly at the base (Flora of China, n.d.). Six to nine lateral veins are on each side of the mid rib (Flora of China, n.d.). Abaxially

the veins are somewhat raised, and adaxially they are obscure (Flora of China, n.d.). Leaves are glossy and dark green adaxially, and abaxially are white to grey and glabrous (Crûg Farm Plants, n.d.; Flora of China, n.d.). Petioles are 2-4.5 cm (Flora of China, n.d.).

The Flora of China states the flower color for the whole genus *Rhodoleia* but does not state a flower color specifically for *R. parvipetala* (Flora of China, n.d.). Notes from the isotype examined state the flower is crimson (Henry 00043466, 1896-1899). Crûg Farm Plants lists the flower color as “bright pink”. Petals are spatulate, 15-18 mm long, and 5-6 mm wide (Flora of China, n.d.). The inflorescence is 2-2.5 cm, with five to seven pubescent involucre bracts at the base (Flora of China, n.d.). Bracts are ovate to rounded and 7-10 mm in length (Flora of China, n.d.). Unlike *R. championii*, bracteoles are absent in *R. parvipetala* (Flora of China, n.d.). The isotype clearly shows the pubescence on the involucre bracts (Henry 00043466, 1896-1899). Flowering time is inconsistent in the literature and is described as May to April by the *Flora of China*, or mid to late April by Crûg Farm Plants. Crûg Farm Plants also states that in cultivation in the United Kingdom, *R. parvipetala* is likely to flower from spring to summer.

The ovary is glabrous (Flora of China, n.d.). Fruit droop on a 1-1.5 cm peduncle and are the characteristic woody capsule of the genus (Flora of China, n.d.). They are relatively small, being just 0.8-1 cm in length, holding many small flattened seeds, and the whole infructescence is 2.5-3.5 cm wide (Flora of China n.d.). Fruiting period is April to September (Flora of China, n.d.).

*R. parvipetala* is native to three provinces in China and northern Vietnam (Flora of China, n.d.; Fang, Wang, & Tang, 2011). Fang et al. give more detail to the

native range in the three provinces in China; west Guangxi, southeast Guizhou, and southeast Yunnan (2011). *R. parvipetala* is found on slopes in evergreen forests at elevations around 1000 m (Flora of China, n.d.). The isotype collected in Yunnan Province was collected at approximately 1500 m (Henry 00043466, 1896-1899). Cultural requirements are described by Crûg Farm Plants as full sun to light shade, in freely draining organic soil that is neutral to acidic, and to grow specimens in a “sheltered warm position” in the United Kingdom. This species is not listed on the IUCN Red List (IUCN Red List, 2018). The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 60 *Rhodoleia parvipetala*: BGCI Institution Report and BGCI Collections Survey

<i>Rhodoleia parvipetala</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	7	1
Countries	5	1
Accessions	N/A	1
Wild Provenance	N/A	0
Plants	N/A	1

#### 2.23.6 *Rhodoleia stenopetala* H.T. Chang

Original Publication: H. T. Chang, Acta Sci. Nat. Univ. Sunyatseni. 1959(2): 31. 1959.

The *Flora of China* lists the common name as “窄瓣红花荷” or “zhai ban hong hua he” (n.d.). There are no known synonyms to this species, and it appears to

have been stable in the literature since its publication in 1959. *R. stenopetala* does not appear to be cultivated in North America or Europe.

Described by *Flora of China* as a tree growing to 20 m, the descriptive text on a vouchered specimen states that it came from a young specimen that was 10 m tall (“Harvard University Herbaria and Library”, 1933). This voucher is an isotype for the species. Observation of this voucher showed thick stems with large leaf scars alternating on the stem (1933). Like all *Rhodoleia*, *R. stenopetala* is evergreen with alternate leaf arrangement (Flora of China, n.d.).

Leaves are ovate to broadly ovate, and 6-10 cm wide and 4-6.5 cm long (Flora of China, n.d.). The rounded to obtuse apex helps distinguish *R. stenopetala* from the other species, whereas the obtuse to acute apex is not distinguishing (Flora of China, n.d.). The leaf is strongly three-veined at the base, and the mid-vein is raised abaxially (Flora of China, n.d.). On the vouchered specimen, the midvein was very prominently raised (Liang 00043469, 1933). The Flora of China describes the adaxial surface as dark-green and somewhat shiny, the isotype examined also showed the darker adaxial surface (Flora of China, n.d.; Liang 00043469, 1933). Abaxially the leaves are whitish-gray, and again the isotype, despite its age, appeared to be consistent with this characteristic (Flora of China, n.d.; Liang 00043469, 1933). Petioles are stout, glabrous, and 3-5 cm in length (Flora of China, n.d.). The petioles on the isotype appeared to be quite long in comparison to the leaf size (Liang 00043469, 1933).

Flowers are described as “bright red” on the isotype voucher notes from Harvard Herbaria and Library (1933). *R. stenopetala* has the narrowest petals in the genus, being just 1.5-3 mm in width (Flora of China, n.d.). The linear shape of the petals is also distinct (Flora of China, n.d.). The inflorescence is capitate and 2 cm long

(Flora of China, n.d.). The base of the inflorescence is covered in 10 involucre bracts, each bract is ovate to rounded and 5-9 mm in length (Flora of China, n.d.). This species has stellate pubescence on the abaxial side of the bracts (Flora of China, n.d.).

In the literature, flowering time is described as March to June, but as with other species in this genus, the resources used in this discussion for *R. stenopetala* are not consistent. (Flora of China, n.d.). The isotype shows reproductive structures that are at the end of their flowering phase. The isotype was collected on January 10<sup>th</sup>, 1933 (Liang 00043469, 1933). However, the expedition dates listed on the voucher were March 1933 to June 1934 (Liang 00043469, 1933). Unless this specimen was collected outside of the expedition timeline given, this would have been collected on January 10<sup>th</sup>, 1934. Regardless of what year it was collected, the presence of flowers on this voucher in January, and the flower color noted as “bright red” at this time, suggest that either the specimen was flowering at this time, or the spent inflorescence were remaining mostly intact almost a year after blooming. Another species in the genus, *R. championii*, is noted to flower December to March, or February to April depending on what source is referenced (Gu, Luo, Zhang, & Renner, 2010; Flora of China, n.d.). A similar discrepancy of flowering time in literature versus voucher collection time is described below in *R. forrestii*. Winter flowering periods are common in other taxa in the Hamamelidaceae as well. The Flora of China describes the fruit as ovoid to globose capsules in groups of five. These clusters are 2.5 cm wide and are present July to September (Flora of China, n.d.).

*R. stenopetala* is native to isolated and small ranges across Yunnan, Guanxi, Guangdong, and Hainan (Fang, Wang, & Tang, 2011). In 2003, the genus was first documented in Thailand, it was discovered in Kaeng Krachan National Park (Suddee,

& Middletown, 2003). The Flora of China describes the native habitat as evergreen forests at elevation of 600 to 1000 meters (Flora of China, n.d.). The voucher notes of *R. stenopetala* state that it was collected “midway up a mountain in a shaded forest” (Liang 00043469, 1933). This specimen was collected by H.Y. Lian in Hainan, China, and was previously listed as *R. parvipetala*; *R. stenopetala* had yet to be described (Liang 00043469, 1933). *R. stenopetala* is not listed as being of conservation concern (IUCN Red List, 2018). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.23.7 *Rhodoleia* Cultivars**

Two cultivars of *Rhodoleia* were found in the literature; *R. henryi* ‘Scarlet Bells’, and *R. henryi* ‘Takashitasei’ (also found spelled as ‘Takeshitasei’) (JC Raulston Arboretum, n.d.; Delaware Center for Horticulture, 2016). The cultivar ‘Scarlet Bells’ is available for sale through Hawksridge Farms in Hickory, North Carolina, and other online retailers. At the time of this publication, the only sources for the name ‘Takashitasei’ or ‘Takeshitasei’ are an online post referencing the plant from Urban Earth in Seattle, Washington, and a listing as an offered plant in the Delaware Center for Horticulture’s 2016 Rare Plant Auction listing. These two cultivars are listed below, and additional details can be found in Appendix A for each cultivar.

*Rhodoleia henryi* ‘Scarlet Bells’

*Rhodoleia henryi* ‘Takeshitasei’

### **2.24 *Sinowilsonia* Overview**

**Nomenclature and Taxonomy:** *Sinowilsonia* is a primitive genus in the subfamily Hamamelidoideae, and is in the tribe Eustigmateae (Zhou, Wu, Zhou, Zhao,



Liu, Qian, & Li, 2014; Li et al., 1999). Other members of the Eustigmataceae include; *Molinadendron*, *Eustigma*, and *Fortunearia* (Rix, & Endress, 2016). Of these genera, *Sinowilsonia* is most closely related to *Fortunearia*, and they resemble each other vegetatively as well (Rix, & Endress, 2016; Weaver, 1976). *Sinowilsonia* is a monotypic genus, represented by the extant species, *S. henryi* (Zhou, Zhao, Bai, & Wang). The genus name is in recognition of English-American plantsman, Ernest Henry Wilson (Gapinski, 2015). For his work plant collecting in China, Wilson was given the moniker “Chinese Wilson” by colleagues, and as one of the collectors of the type specimen of *Sinowilsonia*, the genus was named in his honor (Rix, & Endress, 2016; Missouri Botanical Garden, n.d.). *Sinowilsonia* is a monotypic genus, *Sinowilsonia henryi*, being the only species. There are no known cultivars of this species.

#### **2.24.1 *Sinowilsonia henryi* Hemsl.**

Original Publication: Hemsl., Hooker's Ic. Pl. 29: t. 2817(1906).

*S. henryi* has no English common name, but the Flora of China states the common name as “shan bai sho” or “山白树” (Flora of China, n.d.). The specific epithet “*henryi*” is in recognition of another plantsman, Augustine Henry, whom also did substantial collecting in China. In 1901, Henry and Wilson each collected *Sinowilsonia* in the same area of Hubei Province, China, and from these specimens the species was described (Rix, & Endress, 2016; Gapinski, 2015). It is from a collecting trip in 1907 that Wilson collected seed to bring back for the Arnold Arboretum (Missouri Botanical Garden, n.d.; Gapinski, 2015). The following year the species was introduced into commerce, and until 1980 all specimens in western cultivation could trace their lineage back to this 1907 collection (Spongberg, 1991). An additional

collector, Padre Cipriano Sylvestri collected *Sinowilsonia* around the same period as Henry and Wilson, but sent his specimens to Florence, thus *Sinowilsonia* of a different lineage could be found in Europe (Rix, & Endress, 2016).

Although Ren et al. describe *S. henryi* as having a “graceful shape” and being “suitable to gardens”, most other sources consider this species a botanic novelty that has more historic interest than aesthetic (Ren, Du, Xin, Wang, Yang, Lei, Liu, & Wang, 2018). *Sinowilsonia* is a large shrub or multi-stemmed tree that grows to 20 m, but more typically grows to just 8 m in height and width in garden settings (Gapinski, 2015; Rix, & Endress, 2016; Royal Horticultural Society, n.d.). Stems are brown with a stellate pubescence, and the bark is a dull grey (Dirr, 1998; Rix, & Endress, 2016).

Plants are deciduous, with alternate leaf arrangement (Rix, & Endress, 2016; Dirr, 1998). Leaves are dark green, thin, and large; 10-18 cm in length and 6-11 cm in width (Rix, & Endress, 2016; Dirr, 1998). Petioles are 2 cm in length (Rix, & Endress, 2016). The overall leaf shape is ovate, with a finely toothed to dentate margin, sometimes being entire (Weaver, 1976; Flora of China, n.d.). The leaf base is cordate to asymmetric, with an acute to acuminate apex (Rix, & Endress, 2016; Flora of China, n.d.). Abaxially, veins are prominent with 7-9 lateral veins on each side, and stellate hairs on the entire leaf back (Flora of China, n.d., Rix, & Endress, 2016). Small stipules are present, measuring just 8 mm in length (Flora of China, n.d.).

In habit and leaf *Sinowilsonia* resembles *Fortunearia*, but *Sinowilsonia* has more a pendant inflorescence with a stiff axis, which are less apparent, and all flowers on *Sinowilsonia* are unisexual (Rix, & Endress, 2016). *Sinowilsonia* is typically pentamerous, but variably hexamerous (Li, Bogle, & Klein, 1997). Although most sources state that *Sinowilsonia* is entirely apetalous, Rix, & Endress describe the

petals as “often lacking, but when present are small and lanceolate” (2016).

Inflorescences are unisexual on terminal racemes (Dirr, 1998; Rix, & Endress, 2016).

The lack of bisexual flowers separates *Sinowilsonia* from all other members of the Hamamelidoideae, and Rix, & Endress hypothesize that it may be unique to the entire family (2016).

The male flowers are 6-8 cm in length and are longer than female flowers (Rix, & Endress, 2016). Male flowers lack basal leaves, are cream in color, and have 5 short stamens per flower (Flora of China, n.d.; Rix, & Endress, 2016). Female flowers are less than 6 cm in length, and are held terminally on short shoots (Rix, & Endress, 2016). The female flowers have 1-2 basal leaves, and sepals that are spatulate to ovate with stellate or tomentose pubescence (Flora of China, n.d.; Rix, & Endress, 2016). Styles are 3-5 mm in length and reddish in color, stigmas are reddish as well. Gynoecium has two carpels, and the ovary is stellately tomentose (Rix, & Endress, 2016; Flora of China, n.d.). Rix, & Endress note that the “ovules are not mature at anthesis”, thus delaying the fertilization (2016).

Flowering period is from March to May and occurs before the plants fully leaf out (Rix, & Endress, 2016). *Sinowilsonia* is wind pollinated with fertilization taking place as much as two months after pollination (Rix, & Endress, 2016). The period is June to August (Rix, & Endress, 2016). The fruit is a woody capsule that is sessile and 10 mm in length, the full fruiting structure expands to 10-20 cm when in fruit (Rix, & Endress, 2016; Flora of China, n.d.). The capsules are covered in soft, long hairs that are gray to yellow in color. The capsule has an acute apex, and each capsule contains two dark brown seeds that are 8 mm long (Flora of China, n.d.; Rix, & Endress, 2016).

*Sinowilsonia* is endemic to Central China in the Gansu, Sichuan, Hubei, Shaanxi, Shanxi, and Henan Provinces (Zhou, Zhao, Bai, & Wang, 2018; Rix, & Endress, 2016). Its native habitat is in shady and moist valleys, often near streams, at elevations between 600 and 1,400 m (Zhou et al., 2018; Li, Tian, & Zhang, 2017; Rix, & Endress 2016). In cultivation, some sources suggest that *Sinowilsonia* is difficult to grow, but the Royal Horticultural Society states that it just needs moist, acidic soil in full sun to part shade, and is hardy to  $-15^{\circ}\text{C}$  (Ren, Du, Xin, Wang, Yang, Lei, Liu, & Wang, 2018; Royal Horticultural Society, n.d.).

*Sinowilsonia* is listed as “Nearly Threatened” by the IUCN Red List, “Critically Endangered” on the Red List of China, and “Critically Endangered” on the Key Protected Species List of Shaanxi Province (World Conservation Monitoring Centre, 1998; Zhang, Ji, Li, & Zhou, 2015). Habitat destruction and population fragmentation are the main threats to this species (Li, Tian, & Zhang, 2017). Zhou et al. note that *Sinowilsonia* has “weak natural regeneration” (2018). Populations are fragmented and small in size, ranging from 5 to 50 individuals in populations that produce flowers (Li et al., 2017). Due to its conservation concern, *Sinowilsonia* has been the target of many studies analyzing its genetic diversity. Presently, the chloroplast genome has been completely sequenced and submitted to GenBank under accession number MF687003 (Ren, Du, Xin, Wang, Yang, Lei, Liu, & Wang, 2018). Zhang et al. found that the cultivated populations included in their study showed the lowest level of genetic diversity (2015). This is likely a factor of limited collections of wild material being introduced to cultivation over the last 100 years. Analysis of wild populations showed a low level of genetic divergent, and moderate genetic diversity within populations (Zhang, et al., 2015). Zhang et al. hypothesize that the wide

distribution of *Sinowilsonia* during the Cretaceous and Tertiary periods had great diversity (2015). Once these populations fragmented into modern populations diversity was actually retained, but with continued fragmentation the species is at risk for inbreeding depression and genetic bottlenecking (Zhang, et al., 2015). The table below shows a summary of the BGC I Institution Report and the BGC I Collections Survey for this taxon in *ex situ* collections.

[Table 61 *Sinowilsonia henryi*: BGC I Institution Report and BGC I Collections Survey

<i>Sinowilsonia henryi</i>	BGC I Institution Report	BGC I Collections Survey
Institutions	70	29
Countries	15	9
Accessions	N/A	60
Wild Provenance	N/A	10
Plants	N/A	71

#### 2.24.1.1 *Sinowilsonia henryi* var. *henryi*

Although this variety is not accepted by *The Plant List* or the *International Plant Names Index*, the Flora of China does recognize it, and describes it as having obovate leaves, abaxially pubescent, and growing at elevations of 1,000-1,500 m (Flora of China, n.d.).

#### 2.24.1.2 *Sinowilsonia henryi* var. *glabrescens*

The original publication for this variety is; H.T. Chang, Fl. Republ. Popularis Sin. 35(2): 101. 1979.

*S. henryi* var. *glabrescens* is not considered valid by most sources, but is recognized as a valid name by the Flora of China and Rix, & Endress (n.d.; 2016). The Flora of China describes the leaves as ovate to orbicular, abaxially glabrous, and growing at elevations of 800-1000 m only in South Shanxi (Flora of China, n.d.).

## 2.25 *Sycopsis* Overview

**Nomenclature and Taxonomy:** The genus name *Sycopsis* was first published by Daniel Oliver in 1860 based on *S. griffithiana* from India (Walker, 1944). Traditionally, *Sycopsis* was placed in the Distyliaceae with *Distylium* and *Distiliopsis*, but ITS sequencing supports combining the members of the Distyliaceae with the members of the Fothergillaceae; *Fothergilla*, *Parrotia*, and *Parrotiopsis* (Li, Bogle, & Klein, 1999). As Li, Bogle, and Klein (1999) did not propose a name for the subtribe formed by this merger, the name “Fothergillinae” is used in this thesis. Peter K. Endress predicted this close relationship of *Parrotia* and *Sycopsis* based on the success of the intergeneric hybrid,  $\times$ *Sycoparrotia* (Li, Bogle, & Klein, 1999). Magallón characterizes the modern Fothergillaceae as lacking a fixed merosity of both the perianth and androecium and differing greatly in the reduction of perianth parts (2007).

In 1944, Egbert H. Walker published an extensive paper titled *A Revision of Distylium and Sycopsis (Hamamelidaceae)*. Although, the nomenclature has shifted overtime, the species descriptions are still the best comprehensive resource to date. Walker described six species of *Sycopsis*; *S. griffithiana* Oliv. *S. sinensis* Oliv. *S. laurifolia* Hemsl., *S. dunnii* Hemsl., *S. tutcheri* Hemsl., and *S. salicifolia* H.L. Li ex E. Walker (1944). Presently, only *S. sinensis* is recognized as an accepted name from Walker’s work (The Plant List 1.1, n.d.). *S. griffithiana* is unresolved in most modern sources but is included in the species descriptions below (The Plant List 1.1, n.d.). The

remaining species of *Sycopsis* in Walker's publication are synonyms in the genus *Distyliopsis* and are described in more detail in those sections of this thesis (The Plant List 1.1, n.d.). There is an additional accepted species that was not included in Walker's publication, *S. triplinervia* H.T. Chang (Flora of China, n.d.). Additionally, names such as *S. philippinensis* Hemsl., *S. pingpiensis*, and *S. heterophylla* are found in the literature, but the validity of these names is not supported.

**Description:** *Sycopsis* is an evergreen tree or shrub with alternate arrangement (Walker, 1944). Leaves are simple, leathery, and mostly entire, but sparse teeth are sometimes present apically (Walker, 1944). Leaves are petiolate, stipules are lanceolate and small (Walker, 1944). Flowers are apetalous, and the calyx is arranged in a single whorl (Magallón, 2007, Walker, 1944). *Sycopsis* is unisexual, monoecious or andromonoecious (Walker, 1944). Flowers are held in axillary spikes or racemes (Walker, 1944). Some species have an involucre-like structure enclosing the flowers in bud (Walker, 1944). There are two or more bracts per flower, and the bracts are broad and imbricate (Walker, 1944). Sepals are small, in groups of 1-5, and are similar in appearance to the bracts (Walker, 1944).

The two types of flowers on *Sycopsis* are staminate and perfect flowers (Walker, 1944). The staminate flowers are compact spikes or glomerate heads, pistils are generally absent and there are 7-10 stamens per flower. The stamens are positioned in a ring on a rounded or urn-shaped receptacle (Walker, 1944). The filaments are not of uniform length, and anthers are basally attached (Walker, 1944). Each anther is elliptic with two cells, each cell is longitudinally dehiscent (Walker, 1944). Pistillate or perfect flowers each have two carpels, the ovary is free and covered in long, soft pubescence (Walker, 1944). The receptacle bears one to five sepals and one to ten

stamens (Walker, 1944). The stamens are held closely to the styles, and each flower has two styles (Walker, 1944). Styles are elongated, slender, and not attached to the sepals, allowing them to diverge from the center of the floral structure (Walker, 1944). The stigma is elongated, and some pubescence is present on the inside of the style (Walker, 1944). Within each cell, the ovules are solitary and pendant (Walker, 1944).

The fruit of *Sycopsis* is a rounded woody capsule that is two or four-valved (Walker, 1944). The capsules are covered in long, soft hairs, and have longitudinal dehiscence (Walker, 1944). Seeds are shiny, brown-colored, and ovate to oblong (Walker, 1944). Walker states that some species have seeds that are white colored and have an impressed hilum that is distinct (1944). *Sycopsis* is found in the Philippines, central and southern China, and Assam, India (Walker, 1944).

#### **2.25.1 *Sycopsis griffithiana* Oliv.**

Original Publication: Trans. Linn. Soc. 23: 83. Pl. 8. 1860.

As stated above, *S. griffithiana* is presently considered unresolved. However, it is unclear if it is synonymous with any recognized taxa, and Walker described this species with some detail that might assist others in making an assessment. A summary of Walker's description is outlined here. *S. griffithiana* is a small tree or shrub with pubescent stems (Walker, 1944). Leaves are elliptic to ovate, up to 8 cm long, and 2-3 cm wide (Walker, 1944). The margins are entire, and no note was made about sparse teeth occurring apically on this species (Walker, 1944). Observations from a digitized specimen "3375" housed at Kew does not have any teeth on the margin. Specimen "3375" Walker believes could be the type, and at the least is an isotype. Walker notes that no type specimen was referenced in the original publication of *S. griffithiana*, but based on existing evidence, he believes the above specimen was meant to be the type



(1944). The leaf base is cuneate, and the apex acuminate (Walker, 1944). There are eight vein pairs on either side of the margin, and both the veins and margin are impressed adaxially, and raised abaxially (Walker, 1944). The petiole is glabrous or sparsely pubescent and is 7 mm long (Walker, 1944). Walker mentions that the petiole of *S. griffithiana* is channeled, a characteristic which is unique to this species (1944).

The inflorescence is a congested, head-like spike (Walker, 1944). Flowers are bracteate, are stellately pubescent, and have up to eight stamens per flower (Walker, 1944). Walker notes that the calyx tube is adnate to the ovary, and that the non-adnate portion of the calyx tube is internally pubescent (1944). The fruit is a woody capsule, as described for the genus, and is 1.5 cm long (Walker, 1944). This species is native to India (Walker, 1944). Two vouchers of this name are currently held in the Kew herbarium, one being the possible type specimen, “3375” collected in India from an expedition that spanned 1862 to 1863 (Walker, 1944). No institutions reported this taxon in either the BGCI Institution Report or the BGCI Collections Survey.

### **2.25.2 *Sycopsis sinensis* Oliv.**

Original Publication: Hook. Ic. Pl. 20: 1931. 1890, 29: p. 2834. 1907

The Flora of China lists the Chinese names of “水丝梨” or “shui si li” as local common names, and most English sources call it “Chinese fighazel” (n.d.). The species, *S. formosana* (Kaneh.) Kaneh. & Hatus. is considered a synonym, and the variety *S. sinensis* var. *integrifolia* Diels is as well (The Plant List 1.1, n.d.; Flora of China, n.d.). The Flora of China lists *Distylium formosanum* Kaneh. as another synonym of *S. sinensis* (n.d.). *S. sinensis* appears to be unusual in cultivation. Very few commercial sources offer it for sale in the United States or United Kingdoms. The BGCI Collections Survey listed 55 accessions of *S. sinensis*, representing 84 plants

from 32 institutions. Two of these accessions were of wild origin, but despite being from different institutions, it is believed to share the same provenance.

*S. sinensis* is an evergreen tree growing to 14 m (Walker, 1944). It has gray stems that can be glabrescent or mildly pubescent (Walker, 1944). The bark is smooth, brown or gray in color, and has narrow longitudinal slits (Walker, 1944). The buds are naked (Walker, 1944). Although it is evergreen in its native range, in colder climates it is described as semi-evergreen (RHS Plant Finder, n.d.). The leaves are leather, elliptic to ovate, 5-13 cm long, and 2.5-5 cm wide (Walker, 1944). The margin is entire, or sparsely toothed towards the apex (Walker, 1944). The base is obtuse to rounded, which helps distinguish it from *S. triplinervia*, which has a cuneate base (Walker, 1944). Unlike *S. triplinervia*, *S. sinensis* does not have three prominent basal veins (Flora of China, n.d.). Veins are impressed adaxially, and slightly raised abaxially (Walker, 1944). There are 6-7 vein pairs on either side of the midvein (Walker, 1944). Young leaves are pubescent, and soon become shiny and glabrous (Walker, 1944). Petioles are 1-1.5 cm and can be pubescent or lepidote (Walker, 1944).

Flowers are either male or bisexual (Flora of China, n.d.). Male flowers have a reduced floral cup and a reduced pistil (Flora of China, n.d.). Bisexual flowers have a floral cup that is 1.7-2 mm and a fully formed pistil (Flora of China, n.d.). There are 7-8 flowers arranged spirally on each inflorescence, and the inflorescence is a subglomerate head or head-like spike (Flora of China, n.d.; Walker, 1944). The inflorescence is held terminally on short, lateral branches on a shortened peduncle (Flora of China, n.d.; Walker, 1944). The terminal flower is lacking (Flora of China, n.d.). Large bracts are at the base of each flower, but no bracteoles are present (Flora of China, n.d.). Bracts are ovate or rounded, 6-8 mm long, and have dense, brown

pubescence (Flora of China, n.d.; Walker, 1944). The bracts in this species do enclose the flower when it is in bud (Walker, 1944). Each flower has three small sepals that are 1 mm long and densely pubescent (Walker, 1944).

The Flora of China notes the persistent and pubescent floral cup as being a key identification feature of *S. sinensis* (n.d.). The floral cup is supposed to be larger than that of *S. triplinervia* as well (Flora of China, n.d.). The ovary is superior, but it is enclosed by the floral cup (Flora of China, n.d.). The ovary is pubescent, with one ovule per locule (Flora of China, n.d.). There are five styles per flower and these are bent backwards (Flora of China, n.d.). Anthers are red, ten per staminate flower, and 1.8-2 mm long with an acute apex (Walker, 1944; Flora of China, n.d.). The filaments are yellow and are 1.5 cm long in staminate flowers (Walker, 1944; RHS Plant Finder, n.d.). Flowering period is April to June (Flora of China, n.d.). Woody capsules are globose and smaller than *S. triplinervia* (Walker, 1944). The capsules are arranged spirally along the rachis (Flora of China, n.d.). Fruiting period is July to September (Flora of China, n.d.).

*S. sinensis* is native to 13 provinces in south and central China (Flora of China, n.d.). It occurs in evergreen forests or thickets at 1,300-1,500 m (Flora of China, n.d.). In garden settings, it does well in full sun to part shade and in moist, well drained soils. There is not much consistency as to hardiness, but the RHS Plant Finder states it is hardy to  $-5^{\circ}$  C, and Dirr (1998) has found it hardy to USDA Zone 7. It can be grown in Australia in coastal or cool sites, but is not recommended for inland Australia (Saunders, n.d.). One specimen from the BGCI Collections Survey is in a collection in New Zealand. *S. sinensis* is not listed by the IUCN Red List and does not appear to be of conservation concern in its native range. The table below shows a

summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

Table 62 *Sycopsis sinensis*: BGCI Institution Report and BGCI Collections Survey

<i>Sycopsis sinensis</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	77	31
Countries	15	11
Accessions	N/A	59
Wild Provenance	N/A	5
Plants	N/A	89

### 2.25.3 *Sycopsis triplinervia* H.T. Chang

Original Publication: Acta. Sci. Nat. Univ. Sunyatseni 1960(1) 41 1960.

The *Flora of China* lists the common name of *S. triplinervia* as “三脉水丝梨” or “san mai shui si li” (n.d.). Although this species name is supported by both the *Flora of China* and The Plant List 1.1, the *Flora of China* does state that “it is unclear whether this species belongs to the genus *Sycopsis*” and that additional research is required (n.d.). *S. triplinervia* is an evergreen shrub (*Flora of China*, n.d.). Young stems are stellately tomentose that become glabrescent with age (*Flora of China*, n.d.). Buds are naked (*Flora of China*, n.d.). Leaves are oblong or oblong-lanceolate, 5-14 cm long and 2-6 cm wide (*Flora of China*, n.d.). The margin is entire or with just 1-3 teeth towards the apex (*Flora of China*, n.d.). The base is rounded, and the apex acute (*Flora of China*, n.d.). Three prominent basal veins, only 2-3 lateral vein pairs help to distinguish *S. triplinervia* from *S. sinensis*, and no doubt contribute to its specific

epithet (Flora of China, n.d.). Adaxially leaves are shiny with pubescence only along veins (Flora of China, n.d.). Abaxially, leaves are pubescent, whereas *S. sinensis* is glabrescent (Flora of China, n.d.). Petioles are 6-13 mm long, and are shorter than *S. sinensis* (Flora of China, n.d.). Stipules are small and leathery, leaving small scars when they abscise (Flora of China, n.d.).

The inflorescence of *S. triplinervia* is similar to *S. sinensis*, but has 10 to 12 flowers per inflorescence, and a persistent floral cup that is lepidote and 2mm (Flora of China, n.d.). The ovary is also superior and enclosed by the floral cup, with one ovule per locule (Flora of China, n.d.). There are eight to ten anthers per flower, and each anther is 2-3 mm long (Flora of China, n.d.). The peduncle is 3-5 mm in flower, and 0.8-1 cm when fruiting (Flora of China, n.d.). Both the male and bisexual flowers are sessile (Flora of China, n.d.). Flowering period is April to June (Flora of China, n.d.). Woody capsules are 10-12 mm and are larger than *S. sinensis* (Flora of China, n.d.). The capsules are tomentose, and spirally arranged along the rachis (Flora of China, n.d.). Seeds are ovoid and 6 mm long (Flora of China, n.d.). The fruiting period is June to September (Flora of China, n.d.).

*S. triplinervia* is native to only two provinces in China; Sichuan and Yunnan and is found in forests at elevations of 800-1,000 m (Flora of China, n.d.). This species is not listed by the IUCN Red List and does not appear to be of conservation concern locally. *S. triplinervia* was not reported in the BGCI Collections Survey or in the BGCI Institution Report.

#### **2.25.4 *Sycopsis* Cultivars**

Below are the two known cultivars of *Sycopsis*. Additional details for each cultivar are in Appendix A of this thesis.

*Sycopsis sinensis* ‘Littleleaf’

*Sycopsis sinensis* ‘Variegata’

## 2.26 ×*Sycoparrotia* Overview

**Nomenclature and Taxonomy:** ×*Sycoparrotia semidecidua* is a hybrid of *Sycopsis sinensis* and *Parrotia persica* commonly called the hybrid fig-hazel (Dirr, 1998). Dirr states that it was developed from seed in Basel, Switzerland ca. 1950 in the nursery of a “P. Schoholzer”, whose full name was not able to be located (Dirr, 1998). Iersel (2016) published that this cross was developed by Professor Henry Gerhold of Penn State University and did not specify when this cross took place. It is unclear which took place first.

An article from 1989 states that the hybrid is quite rare in cultivation, and 30 years later it still is uncommon in the trade (Nicholsan, 1989; Iersel, 2016). A brief online search yielded two commercial nurseries in the United States offering ×*Sycoparrotia* for sale; Broken Arrow Nursery, and Forest Farm at Pacifica. In searching online for European sources of ×*Sycoparrotia* yielded four nurseries in the United Kingdom (Bluebell Arboretum Nursery, Ornamental Tree Nurseries, Burncoose Nurseries, and Future Forests), one nursery in France (Andre Briant Jeunes Plants), and one nursery in Germany (Van der Berk Nurseries). Iersel (2016) states that several larger growers in the Netherlands have moderate inventories, but that it is still not common. The BGCI Collections Survey reported 40 accessions of ×*Sycoparrotia*, representing 51 plants and 23 institutions. The oldest of these accessions was from 1970.

**Description:** ×*Sycoparrotia* is a shrub or small tree growing to 4 m (Dirr, 1998). It is semideciduous to evergreen depending on the growing conditions (Dirr,

1998). Leaves are elliptic, 2.5-13 cm long, and 5 cm wide (Royal Horticultural Society, n.d.; Dirr, 1998). During the growing season, the leaves are a lustrous green, turning golden yellow in the fall (Dirr, 1998). Some cultivars produce orange, purple, and red fall color (Iersel, 2016). The flowers are attractive and produced in dense clusters (Royal Horticultural Society, n.d.; Dirr, 1998). These are reddish-brown to yellow in color. The flowers are apetalous, but the red anthers are quite large and turn yellow as the stamens mature (Royal Horticultural Society, n.d.; Dirr, 1998). The flowering period is from February to March, and the flowers are reportedly sterile (Dirr, 1998; Endress, & Anliker, 1968). *×Sycoparrotia* does well in partial shade, in well drained soils, and is hardy to RHS Zone H6 or USDA Zone 8 (Dirr, 1998). However, at the University of Delaware Botanic Gardens a specimen has lived for almost 30 years without winter damage. As this hybrid is of garden origin it is not of conservation concern. The table below shows a summary of the BGCI Collections Survey for this taxon in *ex situ* collections. The BGCI Institution Report did not list this taxon as an option for institutions to report, but even with just the one data set, it is apparent that *×Sycoparrotia semidecidua* has a presence in living collections globally.

[Table 63 *×Sycoparrotia semidecidua*: BGCI Institution Report and BGCI Collections Survey

<i>×Sycoparrotia semidecidua</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	N/A	32
Countries	N/A	8

Accessions	N/A	53
Wild Provenance	N/A	0
Plants	N/A	68

### 2.26.1 ×*Sycoparrotia* Cultivars

×*Sycoparrotia semidecidua* is relatively uncommon in the trade, but four cultivar names appear in the literature. These cultivars are listed below, and Appendix A has additional information for each cultivar. In the BGCI Collections Survey, only ‘Purple Haze’ and ‘Variegata’ were reported.

×*Sycoparrotia semidecidua* ‘Autunno Rosso’

×*Sycoparrotia semidecidua* ‘Prins Claus’

×*Sycoparrotia semidecidua* ‘Purple Haze’

×*Sycoparrotia semidecidua* ‘Variegata’

#### 2.26.1.1 ×*Sycoparrotia semidecidua* ‘Purple Haze’

In the literature ‘Purple Haze’ is mentioned most frequently, but the Royal Horticultural Society lists it as only “Tentatively Accepted” (n.d.). The cultivar ‘Purple Haze’ is described as semi-deciduous with red flowers, red or purple summer foliage, and the fall foliage turning scarlet, orange, yellow or green (Future Forests, n.d.). Four suppliers offer this for sale in the United Kingdoms, and many sources were able to be located in the United States.

#### 2.26.1.2 ×*Sycoparrotia semidecidua* ‘Variegata’

The Royal Horticultural Society lists this cultivar as being “Accepted” (n.d.). This cultivar was reported in the BGCI Collections Survey, but is not commonly



available in the trade. A cursory search for commercial availability yielded Broken Arrow Nurseries, and Buchholz & Buchholz in the United States, Junker's Nurseries in the United Kingdom, and Garden Breizh in France. This cultivar has lighter green leaves than the hybrid, with light pale green to yellow margins (Broken Arrow Nursery, n.d.). Broken Arrow Nurseries states that this cultivar is hardy to USDA Zone 6.

Depending on the date this cultivar name was published, it could be invalidated by article 21.11 of the *International Code of Nomenclature for Cultivated Plants* (ICNCP, 2016). This article states that cultivar names published in Latin after 1959 are not considered valid (ICNCP, 2016). As Dirr (1998) states that the original hybrid cross occurred ca. 1950, this leaves little room for the cultivar to have been developed before this article was enacted.

#### **2.26.1.3 ×*Sycoparrotia semidecidua* 'Prins Claus'**

This cultivar was introduced from the Netherlands by Piet van der Bom (Iersel, 2016). In 2002, van der Bom wrote Queen Beatrix of the Netherlands asking for permission to name this material 'Prins Claus', in honor of her late husband, Prince Claus, Jonkheer van Amsberg (Iersel, 2016). Queen Beatrix's permission was enthusiastically granted (Iersel, 2016). This cultivar is supposed to be more-hardy than 'Purple Haze', is similar in appearance, but has less-dramatic fall color (Iersel, 2016). This cultivar does not appear to be available outside of Van der Berk Nurseries in the Netherlands.

#### **2.26.1.4 ×*Sycoparrotia semidecidua* ‘Autunno Rosso’**

‘Autunno Rosso’ is a recent introduction to the trade, and was registered in the International Register of Ornamental Plant Cultivars: Woody Plants in 2018 (Hatch, & Summers, 2018). It was introduced by Marion and Wendy van Aart in the Netherlands, and appears to have limited commercial availability. (Iersel, 2016). The registered trademark Sartori® corresponds to this plant material (Hatch, & Summers, 2018). ‘Autunno Rosso’ is supposed to be more cold hardy than other cultivars with bright red to dark red fall color (Hatch, & Summers, 2018).

#### **2.27 *Trichocladus* Overview**

**Nomenclature and Taxonomy:** The genus *Trichocladus* is in the subtribe Dicoryphinae within the tribe Hamamelideae, in the subfamily Hamamelidoideae (Magallón, 2007). Four species are recognized as accepted by *The Plant List 1.1*, and these are listed below. In 1933, Hutchinson published *The Genus Trichocladus* and included two additional species, *T. malosanus* Barker and *T. dentatus* Hutch. Neither species is presently recognized as accepted. There is no evidence to suggest that *Trichocladus* is prevalent in cultivation, but it was included in a taxa list of a home garden in South Africa and listed in the “Requests” section of the garden magazine, Veld & Flora in 1994. This suggests that it is known in cultivation, but uncommon. There are no known cultivars of *Trichocladus*.

**Description:** Hutchinson (1933) states that most species of *Trichocladus* have a capitate inflorescence that he describes as “advanced”. Hutchinson (1933) also observed that the southern-most species exhibit the most derived characteristics of the genus. *Trichocladus* is distributed from Ethiopia to South Africa in forested habitats

(Hutchinson, 1933). Only *T. goetzei* is listed as being of conservation concern by the IUCN Red List (Lovett, & Clarke, 1998).

### **2.27.1 *Trichocladus crinitus* Pers.**

Original Publication: Synop. 2, 597 (1807)

The Royal Horticultural Society online plant database lists the common name of *T. crinitus* as hair-branch tree (RHS Plant Search, n.d.). Synonyms of *T. crinitus* are *T. peltatus* Meisn. and *T. vittatus* Meisn. (The Plant List 1.1, n.d.). Magallón (2007) uses *T. crinitus* in their research and states that correct author citation is *T. crinitus* (Thunb.) Pers. In 1995, Rachel and Rod Saunders published the article *A Wild Garden in Suburbia* describing their home garden in Cape Town. In this article, they include *T. crinitus* as one of the taxa they included in their backyard garden (Saunders, & Saunders, 1960). This highlights that *T. crinitus* is not completely unknown in cultivation.

*T. crinitus* is described as an undershrub that is 2-4 m in height, and is often in dense clumps (Breitenbach, 1972). In a 1974 publication, Brickell describes *T. crinitus* as “an interesting tree species” and a “woolly-twigged witch-hazel relative”. Hutchinson (1933) described the young branches as covered in brown villous pubescence, supporting the “woolly twigged” characteristic that Brickell described. The leaves have stellate or tomentose pubescence on the abaxial surface, and a key identification feature of *T. crinitus* is the peltate leaf attachment (Hutchinson, 1933). The flowers are held in capitate heads, and each flower has narrow petals with recurved margins (Hutchinson, 1933).

Hutchinson (1933) states that *T. crinitus* occurs in forests from the coastal province of Natal to the city of George, South Africa. Breitenbach describes *T.*

*crinitus* as forming a “dense undershrub layer in the main high-forest types” in the South African Cape. There is no indication in the literature that *T. crinitus* is of conservation concern locally or globally. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 64 *Trichocladus crinitus*: BGCI Institution Report and BGCI Collections Survey

<i>Trichocladus crinitus</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	6	1
Countries	4	1
Accessions	N/A	2
Wild Provenance	N/A	0
Plants	N/A	3

### 2.27.2 *Trichocladus ellipticus* Eckl. & Zeyh.

Original Publication: Enum. Pl. Afric. Austral. 356 1837

The local common name of *T. ellipticus* is Mkombeti (Maliondo et al., 2000). *T. ellipticus* subsp. *ellipticus* is a synonym of *T. ellipticus* (The Plant List 1.1, n.d.). In 1997, an article was published describing the biodiversity of Ethiopian plant material and listed *T. ellipticus* as a “Potentially Desirable Species” for hardwood timber production (Nigussie, 1997).

The leaves of *T. ellipticus* have stellate or tomentose pubescence on the abaxial surface (Hutchinson, 1933). The leaf shape can be lanceolate or lanceolate-elliptic, and both the apex and base are acuminate (Hutchinson, 1933). Leaves are 3-5 cm long

and 1.5-2.5 cm wide (Hutchinson, 1933). The leaf can be indistinctly peltate, but it is uncommon (Hutchinson, 1933). Flowers are held terminally in a small head, and each flower has narrow petals that are recurved along the margin (Hutchinson, 1933).

In 1980, an article was published commemorating the 50<sup>th</sup> Anniversary of a Swedish expedition to South Africa and Rhodesia (roughly modern-day Zimbabwe) where *T. ellipticus* was described growing with *Podocarpus falcatus*, *Widdringtonia cupressoides*, and *Ekebergia capensis* in relict forest patches surrounding Hells Gate Kloof in the Groot Winterhoek Mountains in South Africa (Nonlindh, 1980).

Hutchinson (1933) states that *T. ellipticus* occurs in forests from the coastal province of Natal to the city of George, South Africa. Nigussie (1997) includes *T. ellipticus* in their publication titled *Biodiversity Conservation in Ethiopia*, so it is assumed here that the range of *T. ellipticus* extends beyond South Africa. There is no indication that this species is presently of conservation concern.

In the BGCI Collections Survey, nine unique accessions were reported of *T. ellipticus*. These were reported from ten institutions in Australia, Belgium, the Netherlands, Switzerland, and the United Kingdom. A total of 18 plants were included in these accessions, and two of the accessions are of known wild origin, both from Kenya. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 65 *Trichocladus ellipticus*: BGCI Institution Report and BGCI Collections Survey

<i>Trichocladus ellipticus</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	11	10

Countries	6	5
Accessions	N/A	11
Wild Provenance	N/A	2
Plants	N/A	20

### 2.27.3 *Trichocladus goetzei* Engl.

Original Publication: Bot. Jahrb. Syst. 49: 455 1913

*T. goetzei* is a tree (Lovett, & Clarke, 1998). The leaves are usually glabrous, with an entire margin, and both the apex and base are rounded (Hutchinson, 1933). The flowers are held in a capitate inflorescence, and each flower has broad petals that are not recurved (Hutchinson, 1933).

*T. goetzei* is distributed in Malawi and Tanzania (Lovett, & Clarke, 1998). The IUCN Red List lists *T. goetzei* as “Vulnerable” (Lovett, & Clarke, 1998). This taxon was not reported in either the BGCI Institution Report or the BGCI Collections Survey.

### 2.27.4 *Trichocladus grandiflorus* Oliv.

Original Publication: Hook. Ic. Pl. t. 1480 (1885)

The leaves of *T. grandiflorus* are usually glabrous, with an acuminate base, and an entire margin (Hutchinson, 1933). *T. grandiflorus* is described by Hutchinson (1933) as being “handsome-flowered” and having a spicate inflorescence.

The flowers are held in a short, spicate inflorescence, and each flower has broad petals that are not recurved (Hutchinson, 1933). Compton describes the “lovely white-flowered” *T. grandiflorus* in his 1960 publication, *The Botany of Swaziland*. This account is the only source that details the flower color of this species. In 1933,

Hutchinson stated that *T. grandiflorus* is found in the “northeastern Transvaal”, a historic province in South Africa that was dissolved in 1994.

Only two accessions of this taxon were reported in the BGCI Collections Survey, both by the Stellenbosch University Botanical Garden in South Africa. In the BGCI Institution Report, two South African institutions reported this taxon. These were the Kirstenboch National Botanical Garden and the Stellenbosch University Botanical Garden. The table below shows a summary of the BGCI Institution Report and the BGCI Collections Survey for this taxon in *ex situ* collections.

[Table 66 *Trichocladus grandiflorus*: BGCI Institution Report and BGCI Collections Survey

<i>Trichocladus grandiflorus</i>	BGCI Institution Report	BGCI Collections Survey
Institutions	2	1
Countries	1	1
Accessions	N/A	2
Wild Provenance	N/A	0
Plants	N/A	3

## Chapter 3

### ASSESSMENT OF LIVING COLLECTIONS

As outlined in the Materials and Methods section of this thesis, the Botanic Gardens Conservation International (BGCI) supplied two datasets for this thesis. One of these datasets, the BGCI Institution Report, were data supplied annually to BGCI by BGCI member gardens containing a list of the taxa within their collections. There are 358 BGCI member gardens and 354 of these institutions were included in the BGCI Institution Report. The other dataset, the BGCI Collections Survey, was composed of data sent to BGCI in response to a request for collections information. The BGCI Collections Survey included responses from 85 institutions that were both BGCI member gardens as well as non-member institutions. The details collected in this survey were; accession numbers, number of specimens within each accession, provenance type, provenance source, and collection details.

The first dataset, the BGCI Institution Report, is a more inclusive data set, contains both subtropical and tropical collections, and more taxa are contained in the reports. The shortcomings of this dataset are that it is only to the taxa level, the living status of material is not verified, the material type is not defined (plant, cuttings, seed, etc.), and provenance details are not included. The second dataset, the BGCI Collections Survey, reports to the plant or specimen level with all the accession information listed above, but it is limited in its representation of global gardens. The BGCI Collections Survey represents mostly temperate gardens (83%), and of those most are gardens within the United States of America (78%). The family distribution extends throughout most temperate regions, and the subtropical to tropical regions of Asia, Australia, Central America, and Africa. The BGCI Collections Survey is a poor



representation of the full family distribution. It is hoped, that by including both data sets, a more complete assessment can be made of the Hamamelidaceae in living collections.

### **3.1 BGCi Institution Report**

A total of 354 institutions were included in the BGCi Institution Report. This represented 41 countries in North America, Europe, Asia, Africa, and Australia. No institutions from Central or South America were included in this data due to lack of data. The taxa reported from this dataset included 76 unique taxa and 25 genera, listed below in Table 67.

Table 67 BGC I Institution Report Number of Institutions Reporting each Taxon

<b>Taxa</b>	<b>Institutions</b>
<i>Chunia bucklandioides</i>	2
<i>Corylopsis alnifolia</i>	1
<i>Corylopsis coreana</i>	14
<i>Corylopsis glabrescens</i>	116
<i>Corylopsis glandulifera</i>	20
<i>Corylopsis glaucescens</i>	2
<i>Corylopsis glaucophylla</i>	1
<i>Corylopsis gotoana</i>	44
<i>Corylopsis griffithii</i>	2
<i>Corylopsis henryi</i>	1
<i>Corylopsis himalayana</i>	8
<i>Corylopsis hypoglauca</i>	6
<i>Corylopsis multiflora</i>	14
<i>Corylopsis pauciflora</i>	119
<i>Corylopsis platypetala</i>	34
<i>Corylopsis sinensis</i>	194
<i>Corylopsis</i> sp.	17
<i>Corylopsis spicata</i>	156
<i>Corylopsis trabeculosa</i>	1
<i>Corylopsis veitchiana</i>	41
<i>Corylopsis willmottiae</i>	35
<i>Corylopsis wilsonii</i>	3
<i>Disanthus cercidifolius</i>	92
<i>Distyliopsis tutcheri</i>	4
<i>Distyliopsis yunnanensis</i>	1
<i>Distylium buxifolium</i>	2
<i>Distylium chinense</i>	2
<i>Distylium elaeagnoides</i>	1
<i>Distylium lepidotum</i>	3
<i>Distylium myricoides</i>	42
<i>Distylium racemosum</i>	100
<i>Distylium</i> sp.	12
<i>Eustigma oblongifolium</i>	1
<i>Exbucklandia populnea</i>	17
<i>Exbucklandia tonkinensis</i>	2
<i>Fortunearia sinensis</i>	33

Table 67 continued

<i>Fothergilla</i> × <i>intermedia</i>	78
<i>Fothergilla gardenii</i>	266
<i>Fothergilla major</i>	207
<i>Fothergilla monticola</i>	11
<i>Fothergilla</i> sp.	18
<i>Hamamelis</i> × <i>intermedia</i>	157
<i>Hamamelis brevipetala</i>	1
<i>Hamamelis japonica</i>	225
<i>Hamamelis macrophylla</i>	12
<i>Hamamelis mexicana</i>	7
<i>Hamamelis mollis</i>	344
<i>Hamamelis ovalis</i>	19
<i>Hamamelis</i> sp.	71
<i>Hamamelis vernalis</i>	415
<i>Hamamelis virginiana</i>	320
<i>Loropetalum chinense</i>	246
<i>Loropetalum</i> sp.	3
<i>Loropetalum subcordatum</i>	2
<i>Maingaya malayana</i>	3
<i>Matudaea trinervia</i>	3
<i>Molinadendron sinaloense</i>	2
<i>Mytilaria laosensis</i>	2
<i>Neostrearia fleckeri</i>	1
<i>Noahdendron nicholasii</i>	1
<i>Ostrearia australiana</i>	2
<i>Parrotia persica</i>	333
<i>Parrotia subaequalis</i>	36
<i>Parrotiopsis jacquemontiana</i>	86
<i>Rhodoleia championii</i>	15
<i>Rhodoleia forrestii</i>	2
<i>Rhodoleia henryi</i>	12
<i>Rhodoleia parvipetala</i>	7
<i>Sinowilsonia henryi</i>	70
<i>Sycopsis sinensis</i>	77
<i>Sycopsis tutcheri</i>	3
<i>Trichocladus crinitus</i>	6
<i>Trichocladus ellipticus</i>	11
<i>Trichocladus grandiflorus</i>	2

Names are listed as reported by the institutions and do not indicate they are necessarily accepted names. More genera were reported in this dataset, than are recognized as accepted by *The Plant List 1.1* but are viewed as accepted in this thesis. The genera reported in this Dataset but not included in *The Plant List 1.1* were; *Maingaya*, *Mytilaria*, *Neostrearia*, and *Ostrearia*. The Plant List genera that the BGCI Institution Report did not report were: *Dicoryphe*, *Embolanthera*, and  $\times$ *Sycoparrotia*. Surprisingly,  $\times$ *Sycoparrotia* was reported on the smaller BGCI Collections Survey. It is assumed that since it is a hybrid of garden origin that BGCI chose to not include it in the BGCI Institution Report.

Appendix C includes a table listing each institution by country and the number of taxa reported. Of the 117 accepted taxa in the family, only 76 of these were reported in the BGCI Institution Report. The taxa with the greatest representation in collections was *Hamamelis japonica*, which was reported by 229 institutions. *Parrotia persica*, and *Hamamelis virginiana* were the next most represented, in 215 and 213 institutions, respectively. By institution, the ten most reported species were members of only four genera. These genera were; *Hamamelis*, *Parrotia*, *Fothergilla* and *Corylopsis*. This is likely due to each of these genera is hardy in temperate regions and contain species of ornamental interest. Most taxa reported are represented in fewer than 50 institutions, and 37 of these taxa are reported in fewer than ten institutions globally. *Sinowilsonia henryi*, which is listed as “Near Threatened” by the IUCN Red List, is actually well represented in collections, as it is reported by 70 institutions. This is counter to the observed trend of greater conservation concern relating to less representation in collections.

### **3.2 BGCi Collections Survey**

A total of 85 institutions were included in the BGCi Collections Survey (Table 68). This represented 19 countries in mostly temperate climates. Five institutions from Australia and New Zealand, one from Kenya, and one from South Africa reported their collections statistics. The institutions from Africa only reported five accessions and two taxa combined. Only two institutions from China were included in this dataset with a combined report of only 12 taxa and 21 accessions.

Table 68 BGCI Collections Survey: Taxa Reported by Each Institution

<b>Institution</b>	<b>Country</b>	<b>Total Taxa (species)</b>
Blue Mountains Botanic Garden, NSW Australia	Australia	8
Botanic Gardens of South Australia	Australia	22
Cairns Botanic Garden	Australia	3
Royal Tasmanian Botanical Gardens	Australia	4
Arboretum Wespelaar	Belgium	27
Ghent University Botanical Garden	Belgium	18
Kalmthout Arboretum	Belgium	18
Planten Tuin Meise	Belgium	29
Memorial University of Newfoundland Botanical Garden	Canada	2
Royal Botanic Gardens	Canada	16
VanDusen Botanical Garden	Canada	22
Jingdong Subtropical Botanical Garden	China	3
Xishuangbanna Tropical Botanical Garden Chinese Academy of Sciences	China	9
Botanical Museum (H), Finnish Museum of Natural History	Finland	5
Helsinki University Botanical Garden	Finland	4
University of Turku	Finland	4
Arboretum National des Barres	France	23
Botanical Garden Caen	France	3
Jardins Suspendus Le Havre	France	13
Museum national d'Histoire naturelle	France	27
Botanischer Garten der Technischen Universität Dresden	Germany	15
Botanischer Garten Frankfurt am Main	Germany	17
ZE Botanischer Garten und Botanisches Museum Berlin-Dahlem	Germany	22
Botanical Garden of Siena Italy	Italy	1
Brackenhurst botanic garden	Kenya	1
Atlantis Botanic Garden	Netherlands	16
Botanic Garden, Delft University of Technology	Netherlands	26

Table 68 continued

Trompenburg Tuinen & Arboretum Rotterdam	Netherlands	22
Von Gimborn Arboretum	Netherlands	22
Pukekura Park	New Zealand	12
Stavanger botanic garden	Norway	5
Rogów Arboretum of Warsaw University of Life Sciences	Poland	21
St. Andrews Botanic Garden	Scotland	10
Botaniese Tui Universiteit Stellenbosch	South Africa	2
Linnaean Gardens of Uppsala	Sweden	5
Botanical Garden of University of Zurich	Switzerland	20
Botanischer Garten der Universitat Bern	Switzerland	12
Bedgebury National Pinetum and Forest	United Kingdom	13
Birmingham Botanical Gardens and Glasshouse	United Kingdom	12
Eden Project	United Kingdom	9
Fossil Plants	United Kingdom	6
Royal Horticultural Society Gardens, United Kingdom	United Kingdom	26
The Sir Harold Hillier Gardens	United Kingdom	33
Westonbirt Arboretum	United Kingdom	15
Arboretum of the Barnes Foundation SJU	United States	21
Arnold Arboretum	United States	18
Bartlett Tree Research Laboratories	United States	34
Brooklyn Botanic Garden	United States	24
Chicago Botanic Garden	United States	28
Connecticut College Arboretum	United States	9
Cornell Botanic Gardens	United States	12
Davis Arboretum	United States	6
Dawes Arboretum	United States	19
Denver Botanic Garden	United States	10
Fullerton Arboretum	United States	2
Ganna Walska Lotusland	United States	1

Table 68 continued

Green Bay Botanical Garden	United States	6
Green Spring Gardens	United States	19
Lincoln Park Zoo	United States	4
Longwood Gardens	United States	21
Missouri Botanical Garden	United States	19
Moore Farms Botanical Garden	United States	19
Morris Arboretum	United States	24
Mt. Cuba Center	United States	11
National Tropical Botanic Gardens	United States	1
New York Botanical Garden	United States	22
Quarryhill Botanical Garden	United States	13
Reiman Gardens	United States	5
San Francisco Botanical Garden	United States	15
Sarah P. Duke Gardens	United States	25
Sister Mary Grace Burns Arboretum	United States	6
Smithsonian Gardens	United States	3
State Arboretum of Virginia	United States	6
The Arboretum, State Botanical Garden of Kentucky	United States	3
The Brenton Arboretum	United States	2
The Huntington	United States	9
The Morton Arboretum	United States	20
The Polly Hill Arboretum	United States	13
Tyler Arboretum	United States	19
U.S. National Arboretum	United States	36
University of California Botanical Garden at Berkeley	United States	19
University of Delaware Botanic Gardens	United States	22
University of Washington Botanic Gardens	United States	25
W.J. Beal Botanical Garden	United States	13
Waimea Valley	United States	1



Some genera were not reported in the BGCI Collections Survey. These genera were; *Chunia*, *Dicoryphe*, *Embolanthera*, and *Eustigma*. These genera are all considered accepted names by *The Plant List 1.1*. *Ostrearia* and *Maingaya* are additional genera not included in the BGCI Collections Survey, but these are considered unresolved by *The Plant List 1.1*. Other genera considered unresolved by the *Plant List 1.1* that were reported in the Survey include; *Neostrearia*, and *Noahdendron*, but these are considered accepted genera in this thesis.

A total of 7,179 accessions were reported in the BGCI Collections Survey. Of these accessions, 583 were of documented wild provenance, and of these 297 are of unique wild provenance. If accessions with no plant quantity were listed as living plants, these were assumed to be represented by a single individual, and masses were assumed to be represented by three plants. Using these assumptions, it was estimated that a total of 12,084 plants were reported, and an estimated 10% of these plants are of wild provenance. A total of 6,089 plants are named cultivars. This accounted for slightly more than half of the plants reported. Appendix D has a table of taxa with the full accession statistics.

By institution, the most frequently reported taxon was *Parrotia persica* but *Hamamelis ×intermedia* was the most prevalent accession. *H. ×intermedia* had 1,529 accessions of the total 7,179 accessions reported in the entire BGCI Collections Survey. Five species of *Hamamelis* were in the top ten reported species by institution. The genus *Hamamelis* accounts for 3,758 accessions of the entire BGCI Collections Survey. The next most prevalent genus at the accessions level is *Fothergilla*, with 1,240 accessions, less than half of the reported *Hamamelis* accessions. Figure 2 shows the disparity of representation between the remaining genera compared to *Fothergilla*

and *Hamamelis*. Table 65 shows collections details at the genus level of the BGCI Collections Survey, and the full table of taxa statistics at the plant level is found in Appendix E.

Figure 2 BGCI Collections Survey: Most Prevalent Genera by Accession

**BGCI Collections Survey: Most Prevalent Genera by Accession**

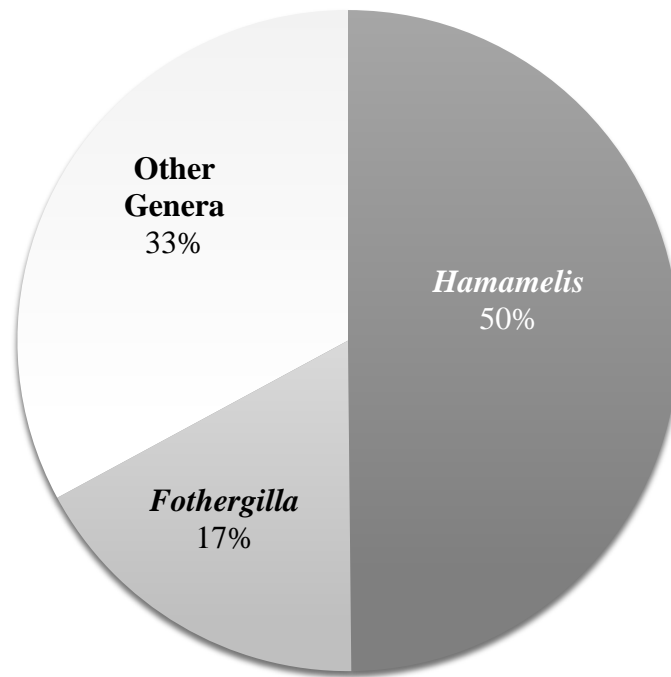


Table 69 BGCI Collections Survey: Genus statistics

Genus	Accessions	Plants
<i>Noahdendron</i>	1	2
<i>Mytilaria</i>	2	2
<i>Neostrearia</i>	2	3
<i>Matudaea</i>	6	9
<i>Molinadendron</i>	10	10
<i>Exbucklandia</i>	12	16
<i>Trichocladus</i>	15	26
<i>Fortunearia</i>	19	28
<i>Rhodoleia</i>	19	22
× <i>Sycoparrotia</i>	53	68
<i>Sycopsis</i>	59	92
<i>Sinowilsonia</i>	60	71
<i>Parrotiopsis</i>	67	104
<i>Disanthus</i>	68	98
<i>Loropetalum</i>	223	575
<i>Distylium</i>	273	317
<i>Parrotia</i>	470	910
<i>Corylopsis</i>	822	1290
<i>Fothergilla</i>	1240	2799
<i>Hamamelis</i>	3758	5642
<b>Total</b>	<b>7179</b>	<b>12084</b>

### 3.3 Analysis of BGCI Data Sets

The institutions and countries included in the BGCI Institution Report represent a large range of the distribution and favorable growing conditions of the Hamamelidaceae. As such, it was expected that more diverse taxa would be found in the BGCI Institution Report, and this expectation was supported by the data. The BGCI Institution Report reported 76 taxa, and the BGCI Collections Survey included 66 taxa. These numbers include some unresolved taxa that are not considered

synonyms. Although the BGCI Institution Report has data only at the taxa level, this information was able to be compared to the taxa found in the BGCI Collections Survey. In addition, data from both sets were compared to the IUCN Red List and local conservation status of taxa to highlight where collections can better support *ex situ* conservation.

### 3.3.1 Data Set Comparison

In both datasets, *Hamamelis* and *Parrotia* are the most reported genera at the institution level. At the species level, *Hamamelis japonica* is the most reported in the BGCI Institution Report, and *Parrotia persica* is the most reported species in the BGCI Collections Survey. *H. ×intermedia* is a hybrid of garden origin and is prevalent in both datasets. This taxon outranking species level taxa suggests that more emphasis is given to ornamental qualities of plant material, than to preserving straight species within collections. Although, species type *Hamamelis* are also well represented in both datasets.

Additionally, the top ten taxa reported in both datasets were almost identical (Table 70 and Table 71). The BGCI Collections Survey reported *Corylopsis sinensis* as a top taxon, but the BGCI Institution Report reported *Corylopsis pauciflora* instead. In the BGCI Collections Survey, *Corylopsis pauciflora* was the 11<sup>th</sup> most common taxa in collections, and in the BGCI Institution Report *C. sinensis* was the 11<sup>th</sup> most common. These datasets sharing the same trends supports the use of the BGCI Collections Survey to predict collections statistics in the BGCI Institution Report and as well as the inverse. The prevalence of temperate species of ornamental merit in both datasets is not surprising, as both datasets contain mostly temperate institutions with horticultural display as a focus.

Table 70 BGCI Collections Survey: Taxa most reported by institution

BGCI Collections Survey: Most Reported Taxa by Institution	Institutions	Accessions
<i>Corylopsis sinensis</i>	44	199
<i>Fothergilla gardenii</i>	44	443
<i>Hamamelis japonica</i>	44	208
<i>Corylopsis spicata</i>	47	155
<i>Hamamelis vernalis</i>	50	573
<i>Hamamelis mollis</i>	52	354
<i>Fothergilla major</i>	55	387
<i>Hamamelis ×intermedia</i>	55	1529
<i>Hamamelis virginiana</i>	59	848
<i>Parrotia persica</i>	63	425

Table 71 BGCI Institution Report: Taxa most reported by institution

BGCI Institution Report: Most Reported Taxa	Institutions
<i>Corylopsis pauciflora</i>	119
<i>Fothergilla gardenii</i>	128
<i>Corylopsis spicata</i>	135
<i>Hamamelis mollis</i>	153
<i>Hamamelis vernalis</i>	154
<i>Fothergilla major</i>	155
<i>Hamamelis ×intermedia</i>	156
<i>Hamamelis virginiana</i>	213
<i>Parrotia persica</i>	215
<i>Hamamelis japonica</i>	229

Analysis of the taxa least reported in collections varied significantly between datasets. This is attributed to the BGCI Institution Report encompassing more institutions across more diverse hardiness zones. To analyze the least reported taxa in collections, the same strategy was used. The BGCI Collections Survey was sorted in

order of least to greatest institutions reported for each taxon. The number of institutions reporting each taxon from the BGC I Institution Report was also sorted this way. The results are in Table 72 and Table 73 below. In each table, the location of the institution holding each taxon was compared to the taxon's native distribution. The institution was considered to occur within the taxon's natural distribution if the institution is located within a state or province in the taxon's native range.

Table 72 BGC Collections Survey: Taxa least reported by institution

BGCI Collections Survey: Taxa least reported by institution	Institutions	Accessions	Wild Collected Accessions	Institution within Species Native Range
<i>Corylopsis alnifolia</i>	Museum national d'Histoire naturelle	2	0	No
<i>Noahdendron nicholasii</i>	The Cairns Botanic Gardens	1	0	Yes
<i>Trichocladus grandiflorus</i>	Botaniese Tui Universiteit Stellenbosch	2	0	No
<i>Corylopsis glaucescens</i>	New York Botanical Garden	1	0	No
<i>Distylium chinense</i>	Xishuangbanna Tropical Botanical Garden	1	0	No
<i>Exbucklandia tonkinensis</i>	FossilPlants FPL	1	1	No
<i>Loropetalum subcordatum</i>	Jingdong Subtropical Botanical Garden	1	1	No
<i>Mytilaria laosensis</i>	Xishuangbanna Tropical Botanical Garden	2	0	No
<i>Trichocladus crinitus</i>	Botanical Garden of University of Zurich, <b>and</b> Botaniese Tui Universiteit Stellenbosch	2 (1 at each institution)	0	No, and Yes
<i>Rhodoleia parvipetala</i>	Bartlett Tree Research Laboratories	1	0	No

Table 73 BGC I Institution Report: Taxa least reported by institution

BGC I Institution Report: Taxa least reported by institution	Institutions	Institution within Species Native Range
<i>Chunia bucklandioides</i>	Shanghai Chenshan Botanical Garden, <b>and</b> South China Botanical Garden, CAS	No, and No
<i>Corylopsis alnifolia</i>	Jardin Botanique Alpin de la Jaÿsinia	No
<i>Corylopsis henryi</i>	Atlanta Botanical Garden	No
<i>Corylopsis trabeculosa</i>	Kunming Botanical Garden	Yes
<i>Distyliopsis yunnanensis</i>	Xishuangbanna Tropical Botanical Garden, CAS	Yes
<i>Distylium elaeagnoides</i>	Hunan Forest Botanical Garden	Yes
<i>Eustigma oblongifolium</i>	Royal Botanic Gardens, Victoria - Melbourne Gardens	No
<i>Neostrearia fleckeri</i>	The Cairns Botanic Gardens	Yes
<i>Noahdendron nicholasii</i>	The Cairns Botanic Gardens	Yes
<i>Parrotiopsis</i> sp.	Bartlett Tree Research Laboratories Arboretum	No

Another taxon not included in these tables that is worth noting is *Ostrearia australiana*. This taxon is listed as unresolved by *The Plant List 1.1*, but is considered accepted in this thesis. *O. australiana* was reported in only two gardens in Australia. Due to its non-ornamental nature, and being native only to Australia, limited



representation in collections is expected. There are only two taxa that appear in both Table 72 and Table 73. These are *Noahdendron nicholasii* and *Corylopsis alnifolia*. The remaining taxa in each table are unique. It is believed that the smaller sample size created the dissimilarity in the individual taxa of each data set, and, with only one exception, all taxa in the tables are poorly represented in collections in either dataset. The exception to this pattern being *×Sycoparrotia semidecidua*. This taxon was not included in the BGCI Institution Report as it is a hybrid of garden origin. If *×Sycoparrotia semidecidua* were to be removed from Table 72, then *Neostrearia fleckerii* would take its place. *N. fleckerii* has two accessions at two institutions in the BGCI Collections Survey and is represented at just one institution in the BGCI Institution Report.

*Disanthus ovatifolius* is reported in the BGCI Collections Survey (Appendix C), but not the BGCI Institution Report. Although, *D. ovatifolius* does have the synonym *Uocodendron whartonii*, this synonym was not reported in the BGCI Institution Report. This highlights that the BGCI Collections Survey is not just a subset of the BGCI Institution Report. This discrepancy is important to note when reviewing the data sets so that it is not attributed to error when the smaller BGCI Collections Survey reports more of a given taxon than the larger BGCI Institution Report.

Another valuable way to look at the two data sets was to see which species were not represented in any living collections. This can be a reference to use when prioritizing acquisitions into living collections. Those species not represented in any global living collections and with either low number of individuals *in situ* or of conservation concern are especially in need of *ex situ* representation. The species that

did not have representation in the BGCI Institution Report and the BGCI Collections Report are listed below.

<i>Corylopsis brevipetala</i>	<i>Dicoryphe noronhae</i>	<i>Embolanthera glabrescens</i>
<i>Corylopsis calicola</i>	<i>Dicoryphe platyphylla</i>	<i>Embolanthera spicata</i>
<i>Corylopsis glaucescens</i>	<i>Dicoryphe retusa</i>	<i>Eustigma balansae</i>
<i>Corylopsis microcarpa</i>	<i>Dicoryphe stipulacea</i>	<i>Eustigma honbaense</i>
<i>Corylopsis obovata</i>	<i>Dicoryphe viticoides</i>	<i>Eustigma lenticillatum</i>
<i>Corylopsis omeiensis</i>	<i>Distyliopsis dunnii</i>	<i>Eustigma oblongifolium</i>
<i>Corylopsis rotundifolia</i>	<i>Distyliopsis lanata</i>	<i>Exbucklandia longipetala</i>
<i>Corylopsis stelligara</i>	<i>Distyliopsis laurifolia</i>	<i>Exbucklandia stellatum</i>
<i>Corylopsis velutina</i>	<i>Distyliopsis salicifolia</i>	<i>Loropetalum lanceum</i>
<i>Corylopsis yui</i>	<i>Distylium annamicum</i>	<i>Matudaea colombiana</i>
<i>Corylopsis yunnanensis</i>	<i>Distylium chungii</i>	<i>Molinadendron guatemalense</i>
<i>Dicoryphe angustifolia</i>	<i>Distylium dunnianum</i>	<i>Molinadendron hondurensis</i>
<i>Dicoryphe buddleoides</i>	<i>Distylium gracile</i>	<i>Rhodoleia macrocarpa</i>
<i>Dicoryphe gracilis</i>	<i>Distylium indicum</i>	<i>Rhodoleia stenopetala</i>
<i>Dicoryphe guatteriifolia</i>	<i>Distylium macrophyllum</i>	<i>Sycopsis griffithiana</i>
<i>Dicoryphe lanceolata</i>	<i>Distylium pingpienense</i>	<i>Sycopsis triplinervia</i>
<i>Dicoryphe laurifolia</i>	<i>Distylium tsiangii</i>	<i>Trichocladus goetzei</i>
<i>Dicoryphe laurina</i>	<i>Distylium stellare</i>	
<i>Dicoryphe macrophylla</i>	<i>Distylium racemosum</i>	

The BGCI Collections Survey was a resource for many cultivar names in this thesis, and the BGCI Institution Report reported additional cultivar names that were not included in the BGCI Collections Survey. Between the two datasets 388 unique cultivars were reported. A list of cultivar names for the family, excluding *Hamamelis*, is found in Appendix A, and additional cultivar details are listed under their respective genera descriptions in this thesis. More than 50% of the plants in the BGCI Collections Survey were named cultivars. It is likely that this percentage holds true for the Global BGCI Institution Report due to the emphasis of horticulture within the

majority of the institutions reporting this data. This high percentage of cultivars in collections is expected as most institutions are focused on horticultural display. However, it is recommended that institutions interested in *ex situ* collections evaluate the prevalence of cultivars vs. species in their collections to ensure the garden's plant material is in line with their collection focus, and perhaps augmenting cultivated collections with species.

### **3.3.2 Combined Data Sets and Conservation Status**

Both datasets were also reviewed for the inclusion of rare or endangered taxa in collections. The IUCN Red List was the main resource used to assess conservation status, but the local conservation status for each taxon is included in the species descriptions of this thesis. At the time of this research, only 13 species in the Hamamelidaceae were listed by the IUCN Red List (IUCN Red List, n.d.). One of these is *Corylopsis pauciflora* which is listed as “Data Deficient”. The remaining species that have IUCN rankings are listed in Table 74. This table also includes collections statistics at the plant, accessions, and taxa level for the BGCI Collections Survey, and just the institution level for the BGCI Institution Report. In this table, duplicate accessions were removed from the BGCI Collections Survey. To calculate the number of plants for each taxon, the quantity was assumed to be one where taxa were listed as “alive” and the current material listed as a “plant”. Taxa listed as a mass were assumed to be three plants.

Table 74 Hamamelidaceae listed by the IUCN Red List

Taxa	IUCN Red List Rank	Unique Accessions: BGCI Collections Survey	Plants: BGCI Collections Survey	Institutions: BGCI Collections Survey	Institutions: BGCI Institution Report	Countries: BGCI Institution Report
<i>Hamamelis virginiana</i>	Least Concern	599	1403	59	213	27
<i>Rhodoleia championii</i>	Least Concern	8	13	4	15	8
<i>Sinowilsonia henryi</i>	Near Threatened	55	81	29	70	15
<i>Chunia bucklandioides</i>	Vulnerable	0	0	0	2	1
<i>Embolanthera spicata</i>	Vulnerable	0	0	0	0	0
<i>Loropetalum subcordatum</i>	Vulnerable	1	1	1	2	2
<i>Maingaya malayana</i>	Vulnerable	0	0	0	3	3
<i>Matudaea trinervia</i>	Vulnerable	5	10	3	3	2
<i>Trichocladus goetzei</i>	Vulnerable	0	0	0	0	0
<i>Corylopsis coreana</i>	Endangered	8	10	7	14	7
<i>Distylium gracile</i>	Endangered	0	0	0	0	0
<i>Molinadendron hondurense</i>	Critically Endangered	0	0	0	0	0

Despite *Maingaya malayana* being listed by the IUCN Red List as

“Vulnerable” is it found in three institutions in three countries; France, Malaysia, and the United Kingdom (IUCN Red List, n.d.). The “Vulnerable” status makes it difficult for it to enter the trade, and thus collections, so it is also expected that *M. malayana* is not represented in the BGCI Collections Survey.

More species of conservation concern were reported in the BGCI Institution Report than the BGCI Collections Survey. The general trend in this data is that species of more conservation concern are less represented in collections. The exceptions to this being *Corylopsis coreana* and *Sinowilsonia henryi*, which have more representation in collections than taxa of less conservation concern. Although, *C. coreana* has more representation in collections than expected, only 14 institutions report this taxon in the BGCI Institution Report. *C. coreana* should be added to living collections where possible, and institutions that house this taxon are encouraged to share this material to increase representation in global living collections.

*Sinowilsonia henryi* appears to be well represented in collections with 81 plants of 55 unique accessions at 29 institutions. The BGCI Institution Report has 70 institutions housing *S. henryi* in 15 countries. The provenance for 13 of the *S. henryi* accessions in the BGCI Collections Survey are of known wild origin, ten of which are of unique provenance. Provenance details for each of the Hamamelidaceae taxa listed by the ICUN Red List are in Table 75.

Table 75 Hamamelidaceae on IUCN Red List vs. Provenance

Taxa	IUCN Red List Rank	Unique Accessions	Wild Collected Accessions	Unique WC Accessions
<i>Hamamelis virginiana</i>	Least Concern	599	94	88
<i>Rhodoleia championii</i>	Least Concern	8	2	2
<i>Sinowilsonia henryi</i>	Near Threatened	55	13	10
<i>Chunia bucklandioides</i>	Vulnerable	0	0	0
<i>Embolanthera spicata</i>	Vulnerable	0	0	0
<i>Loropetalum subcordatum</i>	Vulnerable	1	1	1
<i>Maingaya malayana</i>	Vulnerable	0	0	0
<i>Matudaea trinervia</i>	Vulnerable	5	4	2
<i>Trichocladus goetzei</i>	Vulnerable	0	0	0
<i>Corylopsis coreana</i>	Endangered	8	1	1
<i>Distylium gracile</i>	Endangered	0	0	0
<i>Molinadendron hondurense</i>	Critically Endangered	0	0	0

Taxa of conservation concern with no representation in either dataset include; *Distylium gracile*, *Embolanthera spicata*, *Molinadendron hondurense* and *Trichocladus goetzei*. As these are listed by the IUCN Red List as “Endangered” or “Vulnerable”, and there is limited horticultural merit to each, it is understandable that the representation in collections would be limited. Their conservation status warrants more investigation and perhaps a place in living collections as a part of joint conservation projects between institutions.

The species *Chunia bucklandioides* and *Maingaya malayana* are both listed as Vulnerable by the IUCN Red List, and neither of these taxa were reported in the BGCI Collections Survey. However, these taxa were listed in the BGCI Institution Report.

*Chunia bucklandioides* is only reported in two collections, and both of these collections are located in China. As *C. bucklandioides* is native in just the Hainan island province in China, and is not noted for its ornamental qualities, this poor representation in collections is consistent with expectations (Flora of China, n.d.). It should be noted that the *Flora of China* states that *C. bucklandioides* is listed as “Endangered” by the IUCN Red List (n.d.). This discrepancy is attributed to the *Flora of China* citing a previous version of the IUCN Red List.

*Maingaya malayana* is represented in only three collections within the Global BGCI Collections Survey. These collections are in France, Malaysia, and the United Kingdom. The diversity of countries that hold *M. malayana* is quite interesting, but this novelty is overshadowed by the overall lack of representation in collections. To address this, it is recommended that, where possible, the institutions presently housing this taxon make propagation materials available to sister institutions through *index seminum* or formal partnerships. Replication of existing material, and the addition of more genetically diverse material into collections would assist in *ex situ* conservation efforts.

Table 75 highlights the high percentage of wild provenance material that make up the limited accessions of *Matudaea trinervia*. Like most species listed in these tables, *M. trinervia* is not noted for its ornamental merit. It was only reported by three institutions in both the BGCI Collections Survey and the BGCI Institution Report. Of these accessions, there are ten total plants, of five unique accessions, and two of these accessions are unique wild collected accessions. The three reporting institutions are in the United States and the United Kingdom. *M. trinervia* is endemic to Mexico and, as no institutions from Central or South America were included in either the BGCI

Collections Survey or the BGCI Institution Report, a limited representation of *M. trinervia*, and other Central and South American species, was expected (IUCN Red List, 1998). Collections information from gardens in these regions would greatly improve the collections statistics currently available for this and other taxa from these regions.

*Loropetalum subcordatum* is listed as “Vulnerable” by the IUCN Red List, but with fewer than 50 individual plants *in situ*, this species is considered by Gong (2010) to be “one of the most endangered angiosperms in China.” It was surprising to see this taxon reported in the BGCI Institution Report, but the two institutions that reported it are located in the native range of *L. subcordatum* in China. Both of these institutions list this taxon under its synonym *Tetrathyrium subcordatum*. The species description for *L. subcordatum*, included in this thesis, has additional details on this synonymy. The single accession reported by the BGCI Collections Survey is of wild provenance, and this accession contains only one individual.

*Rhodoleia championii* is listed as being of “Least Concern” by the IUCN Red List. *R. championii* has far less representation in collections in both datasets. Of the eight accessions of *R. championii* in the BGCI Collections Survey two are of unique wild provenance, which is commendable, considering the low representation in collections. *Hamamelis virginiana*, also listed as “Least Concern” has very high representation in collections. In the BGCI Collections Survey, 59 institutions reported *H. virginiana* and 213 institutions reported it in the BGCI Institution Report. The BGCI Collections Survey reported 1,403 plants with 88 of these accessions of unique wild provenance. *H. virginiana* being so well represented in collections helps to ensure conservation of the species in *ex situ* collections.



The final species included on the IUCN Red List, *Corylopsis pauciflora* is listed as Data Deficient (IUCN Red List, n.d.). This species has relatively large representation in collections. The Global Garden Dataset reports 119 institutions housing this taxon, and 42 institutions in the BGCI Collections Survey report it. An estimated 210 plants were reported in the BGCI Collections Survey, representing 80 accessions, three of which are of unique wild provenance. An IUCN Red List rank needs to be assigned to this taxon to ensure proper representation in collections, and to implement appropriate strategies for *in situ* conservation. *C. pauciflora* was represented in 17 countries within the BGCI Institution Report. This high representation in collections is impacted by *C. pauciflora*'s hardiness in temperate regions, and both datasets representing predominantly temperate collections.

### 3.3.3 Discussion

Hardiness, ornamental value, and conservation status are some of the biggest variables impacting the selection of taxa for living collections. As temperate institutions with a focus on ornamental plants were strongly represented in both datasets, it is expected that the data would reflect this. Plants of conservation concern are often more difficult to source, and if conservation is not within the scope of an institution's mission, the extra effort needed to source or collect this material is not justifiable. These trends are summarized in the conceptual model below. With further investigation the data could be assessed to discern how strongly each of these factors impact their presence in living collections.

↓ Conservation Concern + ↑ Ornamental Value + ↑ Hardiness = ↓ Representation  
 ↑ Conservation Concern + ↓ Ornamental Value + ↓ Hardiness = ↓ Representation

Separately the BGCI Collections Survey and the Global Dataset are of value, but they do not provide enough information to assess the entire state of the Hamamelidaceae in global collections. Ideally, each of the institutions included in the BGCI Institution Report would report the depth of information provided in the BGCI Collections Survey, but combining the data, where possible, and noticing trends within the data is still highly informative. Attention to straight species and plants of known conservation concern should be prioritized where possible. The collections information included in this thesis in combination with the conservation status of each taxon can be used to improve representation of the Hamamelidaceae within global living collections and support *ex situ* conservation efforts. In combination with *in situ* conservation strategies species preservation and genetic diversity can be better managed to ensure the survival of each species within the family.

In summary this thesis is a compilation of previous research on the Hamamelidaceae and present collections representation. It provides future researchers with information to tackle the next steps for understanding and conserving this family. It is hoped that future researchers will use the primary cultivar checklist as a starting point for full cultivar registration within the family. Additionally, the species descriptions can be used to aid researchers in targeted species investigations, the collections data can aid institutions in building collections with greater conservation impact, as stated above, and finally, the taxa with low populations but no conservation assessment should be prioritized for this assessment. The combination of these efforts ensures that there will be greater representation of key taxa within the Hamamelidaceae in living collections.

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## Appendix A

### HAMAMELIDACEAE CULTIVAR CHECK LIST (EXCLUDING *HAMAMELIS*)

Name	Trade Name	Patent	Introducer
<i>Corylopsis</i> ‘ <b>Struik I</b> ’			
Notes: Name found through BGCI PlantSearch			
<i>Corylopsis</i> ‘ <b>Struik II-1-groen</b> ’			
Notes: Name found through BGCI PlantSearch			
<i>Corylopsis</i> ‘ <b>Struik II-2 rood</b> ’			
Notes: Name found through BGCI PlantSearch			
<i>Corylopsis</i> ‘ <b>Winterthur</b> ’			
Notes: Hybrid of <i>C. spicata</i> and <i>C. pauciflora</i> . 3.5-5 m high. Vase habit. Fragrant. Hardy to USDA 6a. Discovered at Winterthur Museum in Delaware (Bean, & Anisko, 2014)			
<i>Corylopsis glabrescens</i> ‘ <b>Chollipo</b> ’			Chollipo Arboretum, South Korea
Notes: Wide habit to 1.5 m (Bean, & Anisko, 2014). Foliage emerges tinged with bronze (Junker, n.d.). Fall color golden (Junker, n.d.). Flower light yellow, fragrant, March-April. (Bean, Anisko, 2014).			
<i>Corylopsis glabrescens</i> ‘ <b>Lemon Drop</b> ’			
Notes: Accepted (RHS, n.d.). Low-growing, dense habit (Junker, n.d.). Foliage smaller (Junker, n.d.). Numerous, pendulous racemes. Fragrant flowers. Foliage ovate to orbicular (Pan-Global Plants, n.d.).			
<i>Corylopsis glabrescens</i> ‘ <b>Longwood Chimes</b> ’			
Notes: Fragrant. Larger flowers. Later flowering period. (Bean, & Anisko, 2014)			
<i>Corylopsis glabrescens</i> ‘ <b>March Jewel</b> ’			Camellia Forest
Notes: Dwarf habit. Early flowering period. Also listed as <i>C. gotoana</i> (Dirr, 1998)			
<i>Corylopsis gotoana</i> ‘ <b>March Jewel</b> ’			
Notes: Prostrate habit. Shortest cultivar. Difficult to source (Bean, & Anisko, 2014)			
<i>Corylopsis himalayana</i> ‘ <b>Winter Glow</b> ’			Piroche Plants
Notes: Shrub or tree habit. Up to 4.5 m height. Blue-green foliage. Flowers pale yellow, late winter to early spring.			
<i>Corylopsis pauciflora</i> ‘ <b>Red Leaf</b> ’			
Notes: Cultivar used in 2015 study by Hatmaker et al., herbarium vouchers deposited during this study.			
<i>Corylopsis sinensis</i> ‘ <b>Hemelrijk</b> ’			



Notes: Located through BGCI PlantSearch			
<i>Corylopsis sinensis</i> ‘Spring Purple’			Hillier Nursery
Notes: 2.5 m height. New foliage purple. Flower yellow, April-May. (Bean, & Anisko, 2014)			
<i>Corylopsis sinensis</i> ‘Tosa Kasumi’			
Notes: Located through BGCI PlantSearch			
<i>Corylopsis spicata</i> ‘Aurea’			
Notes: Likely a synonym to 'Golden Spring'. Yellow foliage. (Bean, & Anisko, 2014)			
<i>Corylopsis spicata</i> ‘Golden Spring’		PP13821	Seiju Yamaguchi
Notes: Chance seedling from Gifu Prefecture, Japan. Often confused for 'Aurea' and might be identical. Yellow foliage. Flower yellow, April-May. (Bean, & Anisko, 2014)			
<i>Corylopsis spicata</i> ‘Ogon’			
Notes: Foliage emerges golden-yellow, maturing to chartreuse (Nurseries Caroliniana, n.d.).			
<i>Corylopsis spicata</i> ‘Red Eye’			
Notes: Only available in Europe. Cultivated for red anthers that appear as red stripes on yellow flower (also found in straight species) (Bean, & Anisko, 2014). Habit spreading, and foliage grey-green (Larch & Cottage, n.d.).			
<i>Disanthus cercidifolius</i> ‘Ena Nishiki’			
Notes: Foliage with cream-white variegation, fall color burgundy and pink, to 2.4 m tall (Broken Arrow, n.d.).			
<i>Disanthus cercidifolius</i> ‘Gold Leaf’			
Notes: Located through BGCI PlantSearch			
<i>Disanthus cercidifolius</i> ‘Golden Crown’			
Notes: Foliage with a yellow-gold margin (Weathington, 2007).			
<i>Disanthus cercidifolius</i> ‘Liku’			
Notes: Name tentatively accepted by RHS, n.d.			
<i>Disanthus cercidifolius</i> ‘Mine No Zausteu’			
Notes: Located through BGCI PlantSearch			
<i>Disanthus cercidifolius</i> ‘Rikov’			
Notes: Located through BGCI PlantSearch			
<i>Disanthus cercidifolius</i> ‘Rikyu’			
Notes: Yamaguchi-san inventor. Shorter internodes, upright, dense habit. Foliage blue-green. 1.2-1.8 m tall (Broken Arrow, n.d.).			
<i>Disanthus cercidifolius</i> ‘Seiju Yamaguchi’		PP13823	Hines Nurseries, Inc.

Notes: Seiju Yamaguchi inventor. Chance seedling. Foliage variegated with cream-yellow on silver blue-green leaves (USPP13823, 2000).			
<b><i>Disanthus cercidifolius</i> ‘Sirakawanisiki’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Disanthus cercidifolius</i> ‘Yellow Flower’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Distylium</i> ‘Frosty’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Distylium</i> ‘Hawksridge Dwarf’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Distylium</i> ‘Mr. Ishiâ’s Variegated’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Distylium</i> ‘PIIDIST-I’</b>	Emerald Heights®	PP24410	Plant Introductions, Inc.
Notes: M. Dirr inventor. <i>Distylium racemosum</i> × <i>D. myricoides</i> . Compact upright-spreading habit. New foliage yellow-green. Dark green summer foliage. Red-purple flower. (USPP24410, 2011)			
<b><i>Distylium</i> ‘PIIDIST-II’</b>	Blue Cascade®	PP24409	Plant Introductions, Inc.
Notes: M. Dirr inventor. <i>Distylium myricoides</i> × <i>D. racemosum</i> . Compact, spreading habit. Maroon-purple new foliage. Dark blue-green summer foliage. Red-maroon flower. (USPP24409, 2011)			
<b><i>Distylium</i> ‘PIIDIST-III’</b>	Coppertone™	PP25304	Plant Introductions, Inc.
Notes: J. Kardos inventor. Compact, rounded habit. Purple new foliage. Blue-green summer foliage. Red-maroon flower. (USPP25304, 2013)			
<b><i>Distylium</i> ‘PIIDIST-IV’</b>	Linebacker™	PP25984	Plant Introductions, Inc.
Notes: M. Dirr, & J. Kardos inventors. Compact, upright habit. Red new foliage. Dark green, shiny summer foliage. Disease and insect resistant. Tolerates wet and dry soils. (USPP25984, 2013)			
<b><i>Distylium</i> ‘PIIDIST-V’</b>	Cinnamon Girl®	PP27631	Plant Introductions, Inc.
Notes: R. Helvick, O. McBee, M. Griffith, J. Beasley, & M. Dirr inventors. Compact habit. Red new foliage. Smaller blue-green foliage. Improved cold hardiness. (USPP27631, 2014)			
<b><i>Distylium</i> ‘PIIDIST-VI’</b>	Swing Low®	PP29779	Plant Introductions, Inc.

Notes: M. Dirr, R. Helvick, O. McBee, M. Griffith, & J. Beasley inventors. Compact, freely branched, mounded habit. Evergreen. Small foliage. New foliage with red-purple markings. Dark green summer foliage. Improved cold hardiness. (USPP29779, 2017)			
<i>Distylium</i> ‘Piroche Form’			Piroche Plants
Notes: Horizontal branching, grows to 1.6-2.4 m (Woodlanders, Inc., n.d.).			
<i>Distylium</i> ‘sPg-3-007’	Spring Frost™	PP25833	Southern Plant Group
Notes: Caroll T. Stephens inventor. Compact habit, 0.5-1 m high. New foliage variegated white. Evergreen. Red flower (USPP25833P2, 2013)			
<i>Distylium myricoides</i> ‘Athens Tower’			
Notes: Upright habit. Foliage dark green. Flowers red, February (Hawksridge Farms, n.d.).			
<i>Distylium myricoides</i> ‘Carolina Compact’			
Notes: Located through the BGCI PlantSearch. Previously listed for sale at the Scott Arboretum plant sale.			
<i>Distylium myricoides</i> ‘Lucky Charm’			Piroche Plants
Notes: Compact. 1.2 m tall, 2.4 m wide. Flowers maroon (Loen Nursery, n.d.).			
<i>Distylium myricoides</i> × <i>D. racemosum</i> ‘Vintage Jade’		PP231282	Plant Introductions, Inc
Notes: M. Dirr inventor. Open pollinated seedling. Compact, mounded, spreading habit. Light green new foliage. Red-maroon flowers (US20120284883P1, 2011)			
<i>Distylium racemosum</i> ‘Akobona’			
Notes: New foliage creamy white, matures to green (Weathington, 2007).			
<i>Distylium racemosum</i> ‘Deep Red’			
Notes: Name unchecked per RHS Plants database.			
<i>Distylium racemosum</i> ‘Ed’s Upright’			
Notes: Located through the BGCI PlantSearch.			
<i>Distylium racemosum</i> ‘Guppy’			Brookside Gardens
Notes: Compact form, to .9 m high. Smaller foliage. (Dirr, 1998)			
<i>Distylium racemosum</i> ‘Hatsushimo’			
Notes: Located through the BGCI PlantSearch			
<i>Distylium racemosum</i> ‘Pendula’			
Notes: Located through the BGCI PlantSearch			
<i>Distylium racemosum</i> ‘Variegatum’			
Notes: Foliage with white to cream colored variegation. (Dirr, 1998)			
<i>Distylium racemosum</i> × <i>D. myricoides</i> ‘Variegatum’			

Notes: Located through the BGCI PlantSearch			
<i>Fothergilla</i> ‘ <b>Hillier</b> ’			
Notes: Name located in Chicago Botanic Gardens " <i>Fothergilla</i> Cultivars" List.			
<i>Fothergilla</i> ‘ <b>Hillier B</b> ’			
Notes: Name located in BGCI PlantSearch and Chicago Botanic Gardens " <i>Fothergilla</i> Cultivars" List.			
<i>Fothergilla</i> ‘ <b>Kelly’s Select</b> ’			Head-Lee Nursery
Notes: Upright habit. Parent plant stoloniderous with yellow to orange fall color. (Dirr, 1998)			
<i>Fothergilla</i> ‘ <b>Phil King</b> ’			
Notes: Name found in Chicago Botanic Gardens " <i>Fothergilla</i> Cultivars" list.			
<i>Fothergilla</i> ‘ <b>Redneck Nation</b> ’			
Notes: Name found in through BGCI PlantSearch at Bartlett Arboretum and through Chicago Botanic Gardens " <i>Fothergilla</i> Cultivars" list.			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>Blue Shadow</b> ’		PP15490	Handy Nursery
Notes: G. Handy inventor. Found as a basal shoot mutation from <i>F. major</i> 'Mount Airy'. Blue-green leaves. Rounder leaves. Fall color yellow, orange, to red. Flowers in spring and sparsely in fall. (USPP15490, 2002)			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>Eastern Form</b> ’			Gossler Farms Nursery
Notes: Synonym 'Eastern'. Darke (2008) states "unremarkable example of the hybrid."			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>KLMfifteen</b> ’	Red Monarch™		Roy Klehm
Notes: 2.4 m tall. Fall color deep orange-red. (Dark, 2008)			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>KLMsixteen</b> ’	May Bouquet™		Roy Klehm
Notes: Fall color yellow to apricot. Flowers profuse, inflorescence to 5 cm long. (Darke, 2008)			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>KLMtwo</b> ’	Beaver Creek	PPAF	Roy Klehm
Notes: Rounded habit, to 1.8 m tall. Foliage blue-green. Fall color red-orange to red. Profuse flowering (Darke, 2008)			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>Red Licorice</b> ’			Bernheim Arboretum
Notes: P. Capiello, & J. Wachter (1995). Low-growing. Foliage small. Fall color red. (Darke, 2008). Leaves deeply channeled, fragrant flower (Larch & Cottage, n.d.).			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>Sea Spray</b> ’			
Notes: Compact oval habit to 1.5 m tall. Foliage blue-green. Fall color not showy. (Darke, 2008)			
<i>Fothergilla</i> × <i>intermedia</i> ‘ <b>Windy City</b> ’			

Notes: 0.6-0.9 m tall. Foliage green and clean. Fall color yellow, orange, to red. Cold hardy to USDA zone 4 (Darke, 2008)			
<b><i>Fothergilla gardenii</i> ‘Aiken County’</b>			Woodlanders Nursery
Notes: Low-growing. Foliage rounded, blue green. Fall color not as showy. (Dirr, 1998)			
<b><i>Fothergilla gardenii</i> ‘Appalachia’</b>			
Notes: Compact to 60 cm. Vigorous growth. Fall color orange-red. (Darke, 2008)			
<b><i>Fothergilla gardenii</i> ‘Berkeley County’</b>			Woodlanders Nursery
Notes: More compact. Foliage rounded, blue green. Fall color not as showy. (Dirr, 1998)			
<b><i>Fothergilla gardenii</i> ‘Blue Mist’</b>			Morris Arboretum
Notes: Delicate, mounded habit. Foliage glaucous blue. Leaves held late, fall color minimized. (Dirr, 1998)			
<b><i>Fothergilla gardenii</i> ‘Bill’s True Dwarf’</b>			Woodlanders Nursery
Notes: Robert McCartney inventor (Leahy, & Anisko, 2008). 1 m tall. Foliage blue-green. Fall color good. (Darke, 2008)			
<b><i>Fothergilla gardenii</i> ‘Brian Upchurch’</b>			
Notes: Tentative name. Located through Royal Horticultural Society "Plants" search. Foliage smaller, to 0.9 m tall (Larch & Cottage, n.d.). 'Carolina' listed as synonym (Larch, & Cottage, n.d.).			
<b><i>Fothergilla gardenii</i> ‘Colleton County’</b>			Woodlanders Nursery
Notes: Taller plant, to 3.7 m height. Foliage rounded, blue green. Fall color not as showy. (Dirr, 1998)			
<b><i>Fothergilla gardenii</i> ‘Eastern Form’</b>			
Notes: Dirr located at Gossler Farms Nursery. The nursery states the foliage smaller, dark green, and yellow to red fall color. (Dirr, 1998)			
<b><i>Fothergilla gardenii</i> ‘Epstein Form’</b>			Harold Epstein (probable)
Notes: Low habit. 0.3-0.5 m high. Small leaf, 3.75 cm long. Fall color excellent, orange-red. (Dirr, 1998) Might be synonym to 'Harold Epstein'			
<b><i>Fothergilla gardenii</i> ‘Glaucophylla’</b>			
Notes: Tentative name. Located through Royal Horticultural Society "Plants" search. Foliage smaller, blue-green color, and fall color orange-red (Larch & Cottage, n.d.).			
<b><i>Fothergilla gardenii</i> ‘Harold Epstein’</b>			Harold Epstein
Notes: Compact habit, to .0.3-0.5 m tall. Small foliage. Fall color yellow to red. Flowers fragrant. Inflorescence to 3.75 cm long. (American Nurseryman, 2014)			

<i>Fothergilla gardenii</i> ‘Jane Platt’			Gossler Farms Nursery
Notes: Selected from a plant in John and Jane Platt's Portland garden. Habit more cascading. Foliage narrow, blue-green. Fall color yellow-red. Flowers longer. (Dirr, 1998)			
<i>Fothergilla gardenii</i> ‘Julia’			
Notes: Located through BGCI PlantSearch and Chicago Botanic Gardens " <i>Fothergilla</i> Cultivars" list			
<i>Fothergilla gardenii</i> ‘September Morn’			Eastern Plant Specialties
Notes: Fall color intense orange to scarlet. Flowers "fuzzy" and white. (Dirr, 1998)			
<i>Fothergilla gardenii</i> ‘Suzanne’			
Notes: Tentative name. Located through Royal Horticultural Society "Plants" search.			
<i>Fothergilla gardenii</i> Woodlanders’ Form			
Notes: Located through BGCI PlantSearch and Chicago Botanic Gardens " <i>Fothergilla</i> Cultivars" list			
<i>Fothergilla gardenii</i> ‘Zundert’			
Notes: Tentative name. Located through Royal Horticultural Society "Plants" search. Compact habit, to 1 m (Larch & Cottage, n.d.).			
<i>Fothergilla major</i> ‘Arkansas Beauty’			Larry Lowman (1995)
Notes: Found in dry habitat, presumed drought tolerant. 1.8 m tall and wide. Foliage thinner and lighter green. Excellent fall color. (Dirr, 1998) "Sparse bloomer and inferior fall color" -Rick Darke (2008)			
<i>Fothergilla major</i> ‘Black Mountain’			Head-Lee Nursery
Notes: Upright, compact habit. Smaller and dark foliage. Fall color yellow-orange (Dirr, 1998). Darke (2008) states "dissappointing in fall color."			
<i>Fothergilla major</i> ‘Bulkyard’			
Notes: Tentative name. Located through Royal Horticultural Society "Plants" search.			
<i>Fothergilla major</i> ‘Feist Red’			Rich Feist
Notes: Large, oval plant. Foliage dark green. Stems stout. Flowers large and fragrant. Red fall color. (Dirr, 1998)			
<i>Fothergilla major</i> ‘Huntsman’			
Notes: Upright habit. Foliage dark green, coarse and abaxially pubescent. Fall color yellow to maroon. (Dirr, 1998)			
<i>Fothergilla major</i> ‘KLMG’	Mystic Harbor™		
Notes: Large habit. (Darke, 2008)			
<i>Fothergilla major</i> Monticola Group			

Notes: Leaves smaller, and thicker than <i>F. major</i> . Fall color attractive. White flowers in April (Junker, n.d.).			
<b><i>Fothergilla major</i> 'Mt. Airy' ('Mount Airy')</b>			Michael Dirr
Notes: Clone selected at Mt. Airy Arboretum. Upright habit to 1.8 m tall. Foliage dark blue-green. Fall color consistent yellow to red fall. Flowers abundant. Vigorous growth, tendency to sucker. (Dirr, 1998) Darke (2008) states this is <i>F. ×intermedia</i> .			
<b><i>Loropetalum chinense</i> 'Atropurpurea'</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Loropetalum chinense</i> 'BENI HIME'</b>		PP27752	Spring Meadow Nursery, Inc.
Notes: Y. Suzuki inventor (2006). Seed parent <i>L. 'Kurobijin'</i> . Prostrate habit. Red-maroon glossy foliage. Foliage small. Flower magenta-pink. (USPP27752P3, 2015)			
<b><i>Loropetalum chinense</i> 'Bicolor'</b>			
Notes: Located through the BGCI PlantSearch within the collections of JC Raulston Arboretum.			
<b><i>Loropetalum chinense</i> 'Bill Wallace'</b>		PP15277	Carolina Nurseries, Inc.
Notes: T.H. Dodd, Jr. inventor (1996). Branch mutation of <i>L. chinense</i> 'Burgundy'. Spreading, procumbent habit. Short internodes, dense foliage. Small leaves. Dark red-green foliage. (USPP15277, 2003)			
<b><i>Loropetalum chinense</i> 'Black Pearl'</b>			
Notes: Compact shrub, to 1.4 m. Foliage dark green with purple tints. Flowers rose-pink (J. Parker Dutch Bulbs, n.d.).			
<b><i>Loropetalum chinense</i> 'China Pink'</b>			
Notes: Small to medium dense shrub. 1.5-2 m tall, 1.5 wide. Foliage purple-red. Flowers pink, flowering in spring and sporadically in summer (Alpine Nurseries, n.d.).			
<b><i>Loropetalum chinense</i> 'Fire Glow'</b>			
Notes: Name located through RHS Plant Finder. Listed as tentatively accepted (RHS Plant Finder, n.d.).			
<b><i>Loropetalum chinense</i> 'Garnet Elf'</b>			
Notes: Name located through BGCI PlantSearch.			
<b><i>Loropetalum chinense</i> Unknown</b>	Garnet Fire™		Garden Debut®
Notes: Introducer, Ted Stephens. Evergreen shrub. 1.2-1.5 m tall. Foliage burgundy and shiny. Flowers dark red, flower fall to to spring (Greenleaf Nursery Co., n.d.).			
<b><i>Loropetalum chinense</i> 'HAKOU'</b>		PP27751	Spring Meadow Nursery, Inc.

Notes: Y. Suzuki inventor (2005). Dwarf, dense, rounded habit. Mature foliage dark green. Flowers white. Heavy fall re-bloom. (USPP27751P3, 2015)			
<b><i>Loropetalum chinense</i> ‘Hillier Form’</b>			
Notes: Spreading, groundcover habit. Foliage green. Flower white. Vigorous growth. (Dirr, 1998)			
<b><i>Loropetalum chinense</i> ‘Hindwarf’</b>		PP12203	Tsh Opco, LLC
Notes: N. Sato inventor. Low, compact habit (.6 m). (USPP12203P2, 1999)			
<b><i>Loropetalum chinense</i> ‘IRODORI’</b>	Jazz Hands Variegated™	PP27713	Spring Meadow Nursery, Inc.
Notes: Y. Suzuki inventor (2004). Tall upright (1.2-1.8 m), spreading habit. Foliage variegated bright pink, white, green, and maroon. Foliage broadly ovate. Flowers bright pink. Additional sparse flowering in fall. (USPP27713P3, 2015)			
<b><i>Loropetalum chinense</i> ‘KURENAI DAIOU’</b>	Jazz Hands Bold™	PP27748	Spring Meadow Nursery, Inc.
Notes: Y. Suzuki inventor (2005). Upright, dense habit to 1.8 m. Foliage emerges pink, matures to burgundy, extremely large. (USPP27748P3, 2015)			
<b><i>Loropetalum chinense</i> ‘KURENAI’</b>	Jazz Hands™ Dwarf Pink	PP27750	
Notes: Plant patent number not located through the USPTO. Evergreen shrub to .9 m. Foliage burgundy with pink accents. Flowers pink. (Proven Winners, n.d.)			
<b><i>Loropetalum chinense</i> ‘NCI002’</b>	Carolina Moonlight™	PP18977	Carroll T. Stephens
Notes: C.T. Stephens inventor (2001). Dense, compact habit. Sage green foliage. Flowers white. (USPP18977, 2006)			
<b><i>Loropetalum chinense</i> ‘Peack’</b>		PP18441	James Bryan Berry
Notes: Seedling of <i>L. chinense</i> Pizzazz™. Mounded habit. Larger foliage with dark pigmentation. (USPP18441, 2005)			
<b><i>Loropetalum chinense</i> ‘Plaze’</b>		PP18375	Plant Development Services, Inc.
Notes: J. B. Berry inventor (2002). Habit globose and compact. Deep-violet abaxial leaf. (USPP18375, 2005)			
<b><i>Loropetalum chinense</i> ‘Plum Gorgeous’</b>			
Notes: Rounded, dense habit. Foliage dark colored. Flowers raspberry colored, spring and autumn (Plant Growers Australia, n.d.).			
<b><i>Loropetalum chinense</i> ‘Razzle- Dazzle’</b>			
Notes: Name located through BGCI PlantSearch and Missouri Botanical Gardens Plant Finder.			



<b><i>Loropetalum chinense</i> ‘Redin Black’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Loropetalum chinense</i> ‘Roseum’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Loropetalum chinense</i> ‘Rubra’</b>			
Notes: Located through BGCI PlantSearch. Likely a synonym to <i>L. chinense</i> var. <i>rubrum</i> .			
<b><i>Loropetalum chinense</i> ‘Rubrum’</b>			
Notes: Flowers pink to red (Missouri Botanical Garden, n.d.). Likely a synonym to <i>L. chinense</i> var. <i>rubrum</i> .			
<b><i>Loropetalum chinense</i> ‘Shang-Red’</b>	Red Diamond™		
Notes: Compact habit, 1.5-1.8 m tall. Foliage dark burgundy, retains color as it matures. Flowers red (Missouri Botanical Garden, n.d.)			
<b><i>Loropetalum chinense</i> ‘SHANG-GREEN’</b>		PP27251	Plant Development Services, Inc.
Notes: R.E. Lee inventor. From an open pollinated breeding program. Upright, dense habit. Green foliage small. (USPP27251P3, 2014)			
<b><i>Loropetalum chinense</i> ‘Shang-lo’</b>		Abandoned	Plant Development Services, Inc.
Notes: T. Meadows, & J. Berry inventors (2003). Dense, low, spreading habit. Dark purple mature foliage. Evergreen. Dark pink flowers. (USPP20090038042P1, 2007)			
<b><i>Loropetalum chinense</i> ‘Shang-white’</b>	Emerald Snow®	PP21738	
Notes: Layered habit. Foliage emerge lime green, mature to green. Flowers white (USPP21738, 2009).			
<b><i>Loropetalum chinense</i> ‘Shibori’</b>			
Notes: Parent plant of <i>L. c.</i> var. <i>rubrum</i> 'Melting Pot'. The patent for 'Melting Pot' states that 'Shibori' has white flowers with a central pink stripe. (USPP15625, 2002)			
<b><i>Loropetalum chinense</i> ‘Shidare’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Loropetalum chinense</i> ‘Snow Muffin’</b>			Bob Head
Notes: Groundcover to 0.5 m. Foliage dark green, large. Flowers white. Sun to shade. (Dirr, 1998)			
<b><i>Loropetalum chinense</i> ‘Snow Panda’</b>			Monrovia Growers
Notes: From seed collected near Yan Chi He, China in 1994. Assigned to ICRA for Unassigned Woody Genera as the time (Susan Pell, Brooklyn Botanic Gardens). Fast growing shrub to 3m. Foliage green. Flowers abundant (Pooler, 2013).			
<b><i>Loropetalum chinense</i> ‘Snowmound’</b>		PP11766	Head Ornaments

Notes: R.H. Head inventor (1988). Compact, globose mounded habit. 5 m height. Mature foliage dark green. Smaller foliage. (USPP11766, 1999)			
<i>Loropetalum chinense</i> ‘sPg-3-002’		PP25832	Southern Plant Group
Notes: Y. Suzuki inventor (2003). Outwardly spreading and mounded habit. Foliage dark-burgundy and green. Flowers white. (USPP25832, 2013)			
<i>Loropetalum chinense</i> ‘Tang Dynasty’			
Notes: Accepted (RHS, n.d.).			
<i>Loropetalum chinense</i> ‘Tokyo Weeping’			
Notes: Located through BGCI PlantSearch			
<i>Loropetalum chinense</i> ‘Variegated Form’			
Notes: Dirr states this is still to be released. Foliage green with cream-white variegation on margins. Flowers white. (Dirr, 1998).			
<i>Loropetalum chinense</i>	Pizazz®		Plant Development Services, Inc.
Notes: Same as 'Hines Purpleleaf', and 'Hines Burgundy'. Compact habit. Excellent red-purple foliage color under specific garden conditions. Dirr states it does not compete with 'Blush' and related cultivars (Dirr, 2008).			
<i>Loropetalum chinense</i>	Snow Dance™		Piroche Plants
Notes: Compact, shrub habit. Foliage smaller, green. Flowers white. Slow growing. (Dirr, 1998). Trademark 4374522 was located for a horticultural plant. Loropetalum was not mentioned in this trademark. Unable to located the cultivar name of this material.			
<i>Loropetalum chinense</i> var. <i>rubrum</i> ‘Bicolor’			
Notes: Foliage emerges maroon, matures olive green. Flowers white with pink stripe. Young plants vigorous. (Dirr, 1998)			
<i>Loropetalum chinense</i> var. <i>rubrum</i> ‘Blush’			
Notes: More compact than 'Burgundy'. To 2.4 m high and wide. Foliage dense, full. Foliage emerges bronze-red mature to dark olive green. Flowers fuchsia. 'Monraz' among at least three cultivars that are identical to 'Blush' (Dirr, 1998).			
<i>Loropetalum chinense</i> var. <i>rubrum</i> ‘Burgundy Blast’			
Notes: Located through BGCI PlantSearch			

<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Burgundy’</b>			
Notes: Groundcover in container, shrub to 4 m in-ground. Foliage emerges rich red-purple matures to purple-green. Old leaves turn orange-red to red. Flowers pink, sporadic after first flowering. Fast growing. (Dirr, 1998)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Carolina Midnight’</b>			
Notes: Foliage glossy, dark purple. Flowers dark fuchsia. (Fine Gardening, 2019).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Carolina Ruby’</b>			
Notes: Located through BGCI PlantSearch			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Chang Nian Hong’</b>	Ever Red®		
Notes: Evergreen shrub. Foliage burgundy. Flowers red, February to April (RHS Plants, n.d.).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Daruma’</b>			
Notes: Compact habit. Foliage rich burgundy. Flowers hot pink (Monrovia, n.d.).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Daybreak’s Flame’</b>			Piroche Plants
Notes: Mounding habit. Evergreen. Foliage emerges pink, matures to green. Flowers hot pink, spring. Likely the same as 'Blush' and 'Monraz', but Dirr states the 'Daybreak's Flame' he grows is unique (Dirr, 1998).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘GriffCRL’</b>		PP16615	Griffith Propagation Nursery
Notes: M.P. Griffith inventor. Branch mutation of <i>L. chinense</i> var. <i>rubrum</i> 'Ruby'. Round habit, 1.8 m. New foliage gray-purple. Flowers red-purple. Flowers March-April, & October (USPP16615, 2005)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Hines Burgundy’</b>			
Notes: Same as 'Hines Purpleleaf', and Pizzazz™. Compact habit. Excellent red-purple foliage color under specific garden conditions. Dirr states it does not compete with 'Blush' and related cultivars (Dirr, 2008).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Hines Purpleleaf’</b>			
Notes: Same as 'Hines Burgundy', and Pizzazz™. Compact habit. Excellent red-purple foliage color under specific garden conditions. Dirr states it does not compete with 'Blush' and related cultivars (Dirr, 2008).			

<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Melting Pot’</b>		PP15625	Tsh Opco, LLC
Notes: B. R. Yinger inventor. Branch sport of <i>L. chinense</i> 'Shibori'. Purple new foliage. Green mature foliage. White flowers (counter to the characteristic of var. <i>rubrum</i> ). (USPP15625, 2002)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Monraz’</b>	Razzleberri®		
Notes: Synonym to 'Blush' (Dirr, 1998)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Mosaic’</b>		PP13693	Tsh Opco, LLC
Notes: Noboru Sato inventor. Evergreen or semi-evergreen. Foliage with yellow variegation on a red-purple leaf. (USPP13693, 2002)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘PIILC-I’</b>	Crimson Fire™	PP25534	Plant Introductions, Inc.
Notes: J.H. Kardos inventor (2008). Open pollination of <i>L. c.</i> var. <i>rubrum</i> 'GriffCRL'. Compact, mounded, spreading habit. Red-purple mature foliage. Evergreen. Pink flowers. Improved hardiness. (USPP25534, 2012)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘PIILC-II’</b>	Sparkling Sangria™	PP25470	Plant Introductions, Inc.
Notes: J.H. Kardos inventor (2008). Large shrub, to 3 m. Foliage red-purple persistent color. Flowers bright red. (USPP25470, 2013).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘PIILC-III’</b>		PP25471	Plant Introductions, Inc.
Notes: J.H. Kardos inventor (2008). Open pollination of <i>L. c.</i> var. <i>rubrum</i> 'GriffCRL'. Compact, mounded habit. Dark-purple mature foliage. Evergreen. Dark pink flowers. Improved cold hardiness. (USPP25471P3, 2013)			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Pink Pearl’</b>			
Notes: Existence of name confirmed, no description (Dirr, 1998).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>‘Pipa’s Red’</b>			Piroche Plants
Notes: Selected from variations of Fire Dance™. Mounding habit. Foliage burgundy, narrow. Foliage color held longer into maturity. Flowers pink. (Dirr, 1998).			
<b><i>Loropetalum chinense</i> var. <i>rubrum</i></b> <b>Piroche Form</b>			Piroche Plants
Notes: Appears synonymous to 'Blush'. Name possible updated to 'Daybreak's Flame' (Dirr, 1998).			

<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Ron's Black'</b>			
Notes: Located through BGCI PlantSearch			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Ruby'</b>			Oriental Trees and Plant Inc.
Notes: Ying Qiang Huo inventor. Compact, rounded habit. Foliage emerges shiny and ruby red. Leaf is rounded and undulated. (Dirr, 1998). 1.2 m high (USPP12203, 1999).			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Sato's Dwarf Red'</b>		PP17669	Tsh Opco, LLC
Notes: Noboru Sato inventor. Low growing habit. Red mature foliage. (USPP17669, 2004)			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Shang-hi'</b>	Purple Diamond®	PP18331	Plant Development Services, Inc.
Notes: T.D. Meadows, Jr., & J.B. Berry inventors (2003). Dense, upright, globose habit. Mature foliage dark purple. Evergreen. Profuse dark pink flowers. Heat and disease tolerant. (USPP18331, 2006)			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Sizzlin' Pink'</b>			Heritage Seedlings
Notes: M. Krautmann inventor. Habit is wide spreading with horizontal branching. 1.2 m tall, 1.8 wide. Foliage emerges red-purple, matures purple-green. Holds color best with high nutrition. Flowers pink, lighter than 'Burgundy' (Dirr, 1998).			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>Small Leaf Form</b>			Oriental Trees and Plant Inc.
Notes: Y.Q. Huo inventor. Leaves 2.5-5 cm long. Foliage green-purple. Flowers light pink, abundant. Re-flowers throughout season. (Dirr, 1998).			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Suzanne'</b>			Michael Dirr
Notes: M. Dirr inventor (1995). Branch sport of <i>L. c.</i> var. <i>rubrum</i> Variegated Form. 0.9-1.2 m tall and wide. Foliage reddish-maroon, sub-rounded. Flowers "rich pink" (Dirr, 1998).			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>Variegated Form</b>			Oriental Trees and Plant Inc.
Notes: More compact rounded habit. Foliage shiny, ruby red with green and maroon variegation. Variegation is not stable, so not introduced in trade (Dirr, 1998).			
<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Zhuzhou Fuchsia'</b>			
Notes: Y.Q Huo brought to State Botanical Garden of Georgia from China (1991). Upright habit, to 3 m tall. Foliage black-maroon, color persists. Leaves elliptic to ovate, 5 cm long, and 2.5 cm wide. Coldy hardy. (Dirr, 1998).			

<i>Loropetalum chinense</i> var. <i>rubrum</i> <b>'Fire Dance'</b>			Piroche Plants
Notes: Upright arching habit to 1.8 m. Foliage emerges ruby red, become red-purple, mature to green. Flowers dark pink. Original plants varied in traits, but a selection of the best became 'Pipa's Red' (Dirr, 1998). Dirr states the name Fire Dance is trademarked, but the only trademark of this name, 73723343 (registered to Bailey Nurseries Inc.) was "dead" August 8, 2009.			
<i>Loropetalum chinense</i> var. <i>rubrum</i>	Plum Delight™		
Notes: Same as 'Hines Purpleleaf', 'Hines Burgundy', and Pizzazz™. Compact habit. Excellent red-purple foliage color under specific garden conditions. Dirr states it does not compete with 'Blush' and related cultivars (Dirr, 2008). Originally trademarked by Hines Nursery (Oregon State University, n.d.). Presently the trademark, 74612385, is owned by Tsh Opco, LLC. and is still live.			
<i>Parrotia persica</i> <b>'Alata'</b>			
Notes: Name located through BGCI PlantSearch			
<i>Parrotia persica</i> <b>'Bella'</b>			
Notes: Upright branching to 4 m. Foliage ovate, emerge deep-purple, and mature to green. Fall color attractive (Larch & Cottage, n.d.).			
<i>Parrotia persica</i> <b>'Belle'</b>			
Notes: Name found in Junker, n.d.			
<i>Parrotia persica</i> <b>'Biltmore'</b>			
Notes: Large, rounded habit. Exfoliating bark. Original specimen described by Dirr (1998) as massive, and over 100 years old. Junker (n.d.) states the branching is low and fall color purple.			
<i>Parrotia persica</i> <b>'Burgundy'</b>			Junker's Nursery
Notes: Foliage emerges purplish. Fall color is more pronounced (Junker, n.d.).			
<i>Parrotia persica</i> <b>'Chrishaven 1'</b>		PP28584	Kenneth G. Christianson
Notes: K.G. Christianson inventor (1992). Chance seedling. Upright, columnar habit. Apical dominance. Branch angles strong. Foliage yellow fall color. (USPP2854, 2015)			
<i>Parrotia persica</i> <b>'Cobhay Upright'</b>			
Notes: Name located through RHS Plants. Tentatively accepted.			
<i>Parrotia persica</i> <b>'Fastigiata'</b>			
Notes: Name located through BGCI PlantSearch.			
<i>Parrotia persica</i> <b>'Felicie'</b>			
Notes: More pronounced fall color (Junker, n.d.). Fall color dark red, flowers appear red, to 4 m tall (Larch & Cottage, n.d.).			
<i>Parrotia persica</i> <b>'Globosa'</b>			
Notes: Name located through RHS Plants. Accepted per 2013 RHS Plant Finder. Name also listed in other sources, but no description accompanied.			

<b><i>Parrotia persica</i> ‘Henny’s Dwarf’</b>			
Notes: Supposed compact form of the species, but unclear how compact (Broken Arrow, n.d.).			
<b><i>Parrotia persica</i> ‘Henry’s Compact’</b>			
Notes: Name located through BGCI PlantSearch.			
<b><i>Parrotia persica</i> ‘Het Plantsoen’</b>			
Notes: Fall color attractive (Larch & Cottage, n.d.).			
<b><i>Parrotia persica</i> ‘Horizontalis’</b>			
Notes: Name located through BGCI PlantSearch.			
<b><i>Parrotia persica</i> ‘Inge’s Ruby Vase’</b>	Ruby Vase®		
Notes: Narrow, upright habit to 9 m high and 4.5 m wide. Foliage emerges red, fall foliage orange-red (Morton Arboretum, n.d.).			
<b><i>Parrotia persica</i> ‘Jennifer Teates’</b>			
Notes: Upright, dense habit. Foliage dark green. Flowers red to maroon (Dirr, 2017).			
<b><i>Parrotia persica</i> ‘JLColumnar’</b>	Persian Spire™	PP24951	JLPN Nursery
Notes: J. Lewis inventor. Upright, narrow habit. 3 m tall, 1 m wide. Foliage emerges purple, matures to dark green with purple accents. Fall color yellow, orange, and red. Bark gray and tan (RHS Plant Search, n.d.). PBR EU 47555. <i>P. persica</i> 'Jlpn01' appears to be a synonym.			
<b><i>Parrotia persica</i> ‘Jodrell Bank’</b>			Jodrell Bank Arboretum
Notes: Small, upright tree. Fall color pronounced (Junker, n.d.)			
<b><i>Parrotia persica</i> ‘Kews Weeping’</b>			
Notes: Dirr (1998) mentions a pendulus form he observed as "Kew form". Unsure if this is a synonym.			
<b><i>Parrotia persica</i> ‘Lamplighter’</b>			
Notes: Foliage green with white and pale green variegation. Fall color flushed with purple. Difficult to establish (Junker, n.d.).			
<b><i>Parrotia persica</i> ‘Mikinori Ogisu’</b>			
Notes: Name located through BGCI PlantSearch. Mikinori Ogisu is a Japanese botanist that supplies unusual plant material to plantsman in the United States and the United Kingdom.			
<b><i>Parrotia persica</i> ‘Pendula’</b>			
Notes: Grafted pendulous form (Junker, n.d.)			
<b><i>Parrotia persica</i> ‘Persian Carpet’</b>			
Notes Name located located through RHS Plant Finder. Listed as tentatively accepted (RHS Plant Search, n.d.).			
<b><i>Parrotia persica</i> ‘Persian Lace’</b>			
Notes: Larch & Cottage (n.d.) list a plant 'Passion Lace' in the same entry as 'Persian Lace', and state the foliage is variegated green, grey, and white.			

<b><i>Parrotia persica</i> ‘Prostrata’</b>			
Notes: Name located through RHS Plant Finder. Listed as tentatively accepted (RHS Plant Search, n.d.).			
<b><i>Parrotia persica</i> Purpleleaf Form</b>			
Notes: New growth bronze-purple. Unclear if this differs from species (Dirr, 1998).			
<b><i>Parrotia persica</i> ‘Red Bull’</b>			
Notes: Name located through BGCI PlantSearch.			
<b><i>Parrotia persica</i> ‘Red October’</b>			
Notes: Collected by Dominique Duhaut in Azerbaijan and given to Philippe de Spoelberch. Selected for orange-red to wine-red fall foliage. New foliage emerges bronze-red and mature to green. Habit is broad, 3.5 m high and 7 m wide (Arboretum Wespelaar, n.d.).			
<b><i>Parrotia persica</i> ‘Select’</b>			
Notes: Foliage emerges lime green with purple margins. Unclear if this is unique (Dirr, 1998).			
<b><i>Parrotia persica</i> ‘Summer Bronze’</b>			
Notes: Name located through RHS Plant Finder. Listed as tentatively accepted (RHS Plant Finder, n.d.).			
<b><i>Parrotia persica</i> ‘Vanessa’</b>			
Notes: Upright, columnar habit (Dirr, 1998). Fall color yellow to red, 10 m tall (Larch & Cottage, n.d.).			
<b><i>Parrotia persica</i> ‘Variegata’</b>			
Notes: Name located through BGCI PlantSearch.			
<b><i>Parrotia persica</i> fastigiata</b>			
Notes: Name located through BGCI PlantSearch.			
<b><i>Parrotia persica</i> New Zealand Form</b>			
Notes: Stock imported from New Zealand that appears to have a smaller leaf and be less cold hardy (Dirr, 1998).			
<b><i>Rhodoleia henryi</i> ‘Scarlet Bells’</b>			
Notes: Ted Stephens introduced the plant to the U.S. from Japan in 2003-2004. Dense, pyramidal shrub. Foliage dark green on top, lighter below. Evergreen. Flower is a dark pink to pure red (Nurseries Caroliniana, n.d.).			
<b><i>Rhodoleia henryi</i> ‘Takeshitasei’</b>			
Notes: Listed only by JC Raulston Arboretum and the Delaware Center for Horticulture's Rare Plant Auction catalog. Evergreen shrub to 3 m. Cold hardy to USDA zone 7. Foliage dark green. Flower red-pink (Delaware Center for Horticulture, 2016).			
<b><i>Sycopsis sinensis</i> ‘Littleleaf’</b>			
Notes: Name found in BGCI PlantSearch.			
<b><i>Sycopsis sinensis</i> ‘Variegata’</b>			



Notes: Name found in BGCI PlantSearch.			
× <i>Sycoparrotia semidecidua</i> ‘ <b>Satori</b> ’	Autunno Rosso		
Notes: Marco Satori introducer, ca. 2016. Fall foliage bright red to dark red. More cold hardy (International Register of Ornamental Plant Cultivars, 2018-2019).			
× <i>Sycoparrotia semidecidua</i> ‘ <b>Prins Claus</b> ’			
Notes: Multi-stem tree or shrub. 2-4 m high. Foliage green. Fall color yellow, orange, or red (Van Den Berk, n.d.).			
× <i>Sycoparrotia semidecidua</i> ‘ <b>Purple Haze</b> ’			
Notes: Foliage emerges tinted purple. Fall foliage attractive. (Junker, n.d.). Flowers yellow, orange-red, grows to 150 cm tall (Larch & Cottage, n.d.).			
× <i>Sycoparrotia semidecidua</i> ‘ <b>Variegata</b> ’			
Notes: Name found in Junker, n.d.			

## Appendix B

### BGCI INSTITUTION REPORT: TAXA BY COUNTRY AND INSTITUTION

Country	Institution	Species
Australia	Blue Mountains Botanic Garden, Mount Tomah	14
Australia	Botanic Gardens of South Australia	22
Australia	Brisbane Botanic Gardens	2
Australia	Cooktown Botanic Gardens	1
Australia	National Arboretum Canberra	1
Australia	National Rhododendron Garden	8
Australia	Royal Botanic Gardens Sydney	7
Australia	Royal Botanic Gardens, Victoria - Melbourne Gardens	17
Australia	Royal Tasmanian Botanical Gardens	7
Australia	St. Kilda Botanic Garden	5
Australia	Tasmanian Arboretum Inc	4
Australia	The Cairns Botanic Gardens	3
Austria	Core Facility Botanical Garden	11
Belgium	Arboretum Groenendaal - Flemish Forest Department - Houtvesterij Groenendaal	7
Belgium	Arboretum Waasland	1
Belgium	Arboretum Wespelaar	25
Belgium	Bokrijk Arboretum	17
Belgium	Botanic Garden Meise	26
Belgium	Ghent University Botanic Garden	8
Belgium	Hof ter Saksen Arboretum	14
Belgium	Kalmthout Arboretum	31
Belgium	Leuven Botanic Garden	8
Canada	Annapolis Royal Historic Gardens	4
Canada	Dominion Arboretum and Central Experimental Farm	3
Canada	Dr. Sun Yat-Sen Classical Chinese Garden	1
Canada	Gardens of Fanshawe College and A.M. Cuddy Gardens	8
Canada	Harriet Irving Botanical Gardens	1
Canada	Memorial University Botanical Garden	1
Canada	Milner Gardens and Woodland	11
Canada	Montreal Botanical Garden	15
Canada	National Tree Seed Centre	1

Canada	New Brunswick Botanical Garden	1
Canada	Niagara Parks Botanical Gardens and School of Horticulture, The	10
Canada	Riverview Horticultural Centre Society, The	1
Canada	Royal Botanical Gardens, Ontario	16
Canada	Royal Roads University Botanical Gardens	6
Canada	Sherwood Fox Arboretum	3
Canada	The University of Guelph Arboretum	4
Canada	Toronto Botanical Garden	7
Canada	Toronto Zoo	1
Canada	University of Alberta Botanic Garden	3
Canada	University of British Columbia Botanical Garden	19
Canada	VanDusen Botanical Garden	21
China	Hangzhou Botanical Garden	1
China	Hunan Forest Botanical Garden	11
China	Hunan Nanyue Arboretum	1
China	Kunming Botanical Garden	14
China	Lushan Botanical Garden	7
China	Nanjing Botanical Garden Mem. Sun Yat-sen	1
China	Shanghai Botanical Garden	2
China	Shanghai Chenshan Botanical Garden	13
China	Shing Mun Arboretum, AFCD	1
China	South China Botanical Garden, CAS	1
China	Xi'an Botanical Garden	1
China	Xishuangbanna Tropical Botanical Garden, CAS	7
China	Yinchuan Botanical Garden (Ningxia)	1
Czech Republic	Arboretum Střední lesnické školy	2
Czech Republic	Dendrological garden of the Silva Tarouca Research Institute for Landscape and Ornamental Gardening	15
Czech Republic	Masaryk University Faculty of Medicine Medicinal Herbs Centre	1
Czech Republic	Palacky University Botanic Garden	1
Denmark	Botanical Garden, Natural History Museum of Denmark	14
Denmark	Royal Veterinary and Agricultural University Arboretum	15
Estonia	Botanical Garden of Tartu University	7
Finland	Arboretum Mustila	2
Finland	Finnish Museum of Natural History / Helsinki University Botanic Garden	4
France	Arboretum National des Barres ( et Fruticetum Vilmorinianum )	21
France	Bibliotheque Centrale	1

France	Conservatoire Botanique National du Brest	17
France	Conservatoire Botanique Pierre Fabre	4
France	Conservatoire et Jardins Botaniques de Nancy	11
France	Jardin Botanique Camifolia	1
France	Jardin Botanique Alpin de la Jaÿsinia	10
France	Jardin Botanique de la Ville de Caen	3
France	Jardin Botanique de la Ville de Lyon	16
France	Jardin Botanique de l'Université de Strasbourg	20
France	Jardin Botanique de Marnay sur Seine	6
France	Jardin botanique de Paris	16
France	Jardin Botanique et Arboretum Henri Gaussen	1
France	Jardin Botanique Exotique " Val Rahmeh "	1
France	Jardin Botanique Yves Rocher	3
France	Jardin des Plantes	21
France	Jardin des Plantes de Paris et Arboretum de Chevreloup	16
France	Jardins des Plantes de l'Université	1
France	Les Jardins Suspendus	15
France	Sentier de Decouverte	3
Georgia	Batumi Botanical Garden	1
Georgia	National Botanical Garden of Georgia	1
Germany - Deutschland	Arboretum Freiburg-Günterstal	13
Germany - Deutschland	Botanic Garden of Rostock University	20
Germany - Deutschland	Botanical Garden University of Duesseldorf	1
Germany - Deutschland	Botanische Gärten der Universität Bonn	22
Germany - Deutschland	Botanischer Garten der Carl von Ossietzky-Universität Oldenburg	15
Germany - Deutschland	Botanischer Garten der Friedrich-Schiller-Universität	15
Germany - Deutschland	Botanischer Garten der J.W. Goethe-Universität	17
Germany - Deutschland	Botanischer Garten der Johannes Gutenberg-Universität Mainz	1
Germany - Deutschland	Botanischer Garten der Justus-Liebig Universität Giessen	14
Germany - Deutschland	Botanischer Garten der Ruhr-Universität Bochum	17

Germany - Deutschland	Botanischer Garten der Technischen Universitaet Darmstadt	17
Germany - Deutschland	Botanischer Garten der Technischen Universitaet Dresden	15
Germany - Deutschland	Botanischer Garten der Universitaet des Saarlandes	13
Germany - Deutschland	Botanischer Garten der Universität Freiburg	16
Germany - Deutschland	Botanischer Garten der Universitat Kiel	11
Germany - Deutschland	Botanischer Garten der Universitat Osnabruck	16
Germany - Deutschland	Botanischer Garten der Universität Ulm	14
Germany - Deutschland	Botanischer Garten der Westfaelischen Wilhelms Universitaet	1
Germany - Deutschland	Botanischer Garten und Botanisches Museum Berlin-Dahlem	1
Germany - Deutschland	Forstbotanischer Garten der Technischen Universitaet Dresden	16
Germany - Deutschland	Forstbotanischer Garten Eberswalde	10
Germany - Deutschland	Forstbotanischer Garten und Arboretum	13
Germany - Deutschland	Grugapark und Botanischer Garten der Stadt Essen	1
Germany - Deutschland	Kurpark Bad Bellingen	6
Germany - Deutschland	Neuer Botanischer Garten der Universität Göttingen	13
Germany - Deutschland	Oekologisch-Botanischer Garten Universitaet Bayreuth	11
Gibraltar	Gibraltar Botanic Gardens	1
Hungary	Eötvös Loránd University Botanic Garden	11
Iceland	Hortus Botanicus Reykjavikensis	1
Ireland	Birr Castle Demesne	1
Ireland	Mount Usher Gardens	1
Ireland	Trinity College Botanic Garden	1
Israel	Jerusalem Botanical Gardens	1
Italy	Centro di Ateneo Orto Botanico dell'Università degli Studi di Padova	8

Italy	Museo Orto Botanico di Roma	2
Italy	Orto Botanico "Carmela Cortini" - Università di Camerino	2
Italy	Orto Botanico "Giardino dei Semplici"	1
Italy	Orto Botanico dell'Università degli studi di Siena	1
Italy	Orto Botanico di Bergamo "Lorenzo Rota"	1
Italy	Orto Botanico di Perugia	1
Kenya	Brackenhurst Botanic Garden	1
Kenya	Multiplant International Medicinal Conservation	2
Latvia	National Botanic Garden of Latvia	7
Lithuania	Botanical Garden of Vilnius University	4
Luxembourg	Arboretum Kirchberg	1
Malaysia	Rimba Ilmu Botanic Garden	1
Netherlands	Arboretum Oudenbosch	14
Netherlands	Belmonte Arboretum	10
Netherlands	Botanic Garden, Delft University of Technology	30
Netherlands	Botanische Tuin Groningen "Domies Toen"	2
Netherlands	Dutch Open Air Museum / Nederlands Openluchtmuseum	1
Netherlands	Hortus Botanicus Amsterdam	11
Netherlands	Stichting Botanische Tuin Kerkrade	16
Netherlands	Trompenburg Gardens & Arboretum	2
Netherlands	Utrecht University Botanic Gardens	15
New Zealand	Auckland Botanic Gardens	13
New Zealand	Gore Public Gardens	1
New Zealand	Pukeiti Garden	10
New Zealand	Pukekura Park	8
New Zealand	Timaru Botanic Garden	2
Norway	Stavanger Botanic Garden	3
Norway	University of Oslo Botanical Garden	10
Poland	Rogów Arboretum of Warsaw University of Life Sciences	17
Portugal	Jardim Botânico da Universidade de Coimbra	1
Portugal	Jardim Botânico da Universidade de Lisboa	1
Portugal	Jardim Botânico da Universidade de Trás-os-Montes e Alto Douro	1
Portugal	Jardim Botânico da Universidade do Porto	1
Portugal	Parque Botânico da Tapada da Ajuda	2
Russian Federation	Botanical Garden of Pyatigorsk State Pharmaceutical Academy	12
Russian Federation	Botanical Garden of the V.L. Komarov Botanical Institute	2
Russian Federation	Botanical Garden-Institute, Ufa Research Center	3
Russian Federation	Main Botanical Garden, Russian Academy of Sciences	8

Russian Federation	Moscow State University Botanical Garden	2
Russian Federation	Novosibirsk Dendropark	1
Singapore	Singapore Botanic Gardens	2
Slovenia	Ljubljana University Botanic Garden	7
Slovenia	Maribor University Botanic Garden	3
South Africa	Kirstenbosch National Botanical Garden	2
South Africa	Stellenbosch University Botanical Garden	2
South Korea	Incheon Arboretum	5
South Korea	Jade Garden Natural Arboretum	9
South Korea	Jeju Botanical Garden, Yeomiji	4
South Korea	Kee-chung-san Botanic Garden	3
South Korea	Keum Kang Arboretum	3
South Korea	Korea Botanic Garden	1
South Korea	Pyunggang Botanical Garden	13
South Korea	Sanghyo Botanical Garden	2
South Korea	The Garden of Morning Calm	2
Spain	Arboretum i Jardí Botànic Pius Font i Quer	2
Spain	Jardi Botanic de Barcelona	1
Spain	Jardí Botànic de la Universitat de València	3
Spain	Jardi Botanic de Soller	5
Spain	Jardín Botánico Atlántico de Gijón	3
Spain	Real Jardín Botánico Juan Carlos I	6
Sweden	The Linnaean Gardens of Uppsala (Uppsala University)	6
Switzerland	Botanischer Garten der Universitaet Zurich	1
Switzerland	Conservatoire et Jardin botaniques de la Ville de Genève	11
Switzerland	Musee et Jardins Botaniques Cantonaux	1
Uganda	Tooro Botanical Gardens	1
Ukraine	Catalogue of Medicinal Plants of Ukrainian Botanic Gardens and Parks	2
Ukraine	Ukrainian National Forestry University Botanic Garden	1
United Kingdom	Bedgebury National Pinetum & Forest	10
United Kingdom	Benmore Botanic Garden	9
United Kingdom	Birmingham Botanical Gardens and Glasshouses	11
United Kingdom	Cambridge University Botanic Garden	11
United Kingdom	City of Leeds Botanic Gardens	1
United Kingdom	City of Liverpool Botanic Gardens	1
United Kingdom	Dawyck Botanic Garden	3
United Kingdom	Eden Project, The	8

United Kingdom	FossilPlants	2
United Kingdom	Glasgow Botanic Gardens	10
United Kingdom	Logan Botanic Garden	5
United Kingdom	Millennium Seed Bank	11
United Kingdom	National Botanic Garden of Wales	12
United Kingdom	Oxford University Botanic Garden	13
United Kingdom	Paignton Zoo Environmental Park	9
United Kingdom	Pine Lodge Pinetum	3
United Kingdom	Royal Botanic Garden Edinburgh	20
United Kingdom	Royal Botanic Gardens Kew (Wakehurst)	18
United Kingdom	Royal Botanic Gardens, Kew	22
United Kingdom	Royal Horticultural Society's Garden, Harlow Carr	11
United Kingdom	Royal Horticultural Society's Garden, Hyde Hall	8
United Kingdom	Royal Horticultural Society's Garden, Rosemoor	11
United Kingdom	Royal Horticultural Society's Garden, Wisley	21
United Kingdom	Sheffield Botanical Gardens	13
United Kingdom	St. Andrews Botanic Garden	13
United Kingdom	Tatton Garden Society/Quinta Arboretum	8
United Kingdom	The Harris Garden	1
United Kingdom	The Sir Harold Hillier Gardens	30
United Kingdom	Thwaite Gardens, University of Hull Botanic & Experimental Garden	1
United Kingdom	Tregothnan Estate	3
United Kingdom	Wentworth Castle Gardens	1
United Kingdom	Westonbirt, The National Arboretum	15
United States of America	Arboretum at Penn State, The	4
United States of America	Arboretum of The Barnes Foundation	18
United States of America	Arnold Arboretum of Harvard University, The	22
United States of America	Atlanta Botanical Garden	36
United States of America	Aullwood Garden MetroPark	4
United States of America	Baker Arboretum	5
United States of America	Bamboo Brook Outdoor Education Center	2



United States of America	Bartlett Tree Research Laboratories Arboretum	29
United States of America	Bayard Cutting Arboretum	7
United States of America	Berkshire Botanical Garden	6
United States of America	Betty Ford Alpine Gardens	1
United States of America	Bickelhaupt Arboretum	4
United States of America	Bishop Museum - Checklist of Cultivated Plants of Hawai'i	1
United States of America	Boone County Arboretum	8
United States of America	Botanic Garden of Smith College, The	17
United States of America	Bowman's Hill Wildflower Preserve	1
United States of America	Boyce Thompson Arboretum	2
United States of America	Brenton Arboretum, The	2
United States of America	Brookgreen Gardens	2
United States of America	Brooklyn Botanic Garden	21
United States of America	Brookside Gardens	18
United States of America	C. M. Goethe Arboretum	8
United States of America	Cape Fear Botanical Garden	2
United States of America	Center for Plant Conservation (USA)	1
United States of America	Charles R. Keith Arboretum, The	27
United States of America	Chicago Botanic Garden	19
United States of America	Cleveland Botanical Garden	9
United States of America	Coastal Maine Botanical Gardens	14

United States of America	Columbus Botanical Garden	2
United States of America	Connecticut College Arboretum	9
United States of America	Cornell Botanic Gardens	12
United States of America	Crosby Arboretum, The	1
United States of America	Davidson College Arboretum	1
United States of America	Dawes Arboretum, The	21
United States of America	Denver Botanic Gardens	9
United States of America	Dixon Gallery and Gardens, The	11
United States of America	Dixon National Tallgrass Prairie Seed Bank at Chicago Botanic Garden	1
United States of America	Donald E. Davis Arboretum	4
United States of America	Dow Gardens	7
United States of America	Duke Farms	2
United States of America	DuPage Forest: Forest Preserve District of DuPage County	2
United States of America	Elisabeth C. Miller Botanical Garden	14
United States of America	Eloise Butler Wildflower Garden & Bird Sanctuary	2
United States of America	Enid A. Haupt Glass Garden	1
United States of America	Fellows Riverside Gardens	9
United States of America	Fernwood Botanical Garden and Nature Preserve	9
United States of America	Florida Botanical Gardens	1
United States of America	Foellinger-Freimann Botanical Conservatory	1
United States of America	Fort Worth Botanic Garden	2

United States of America	Frederik Meijer Gardens & Sculpture Park	7
United States of America	Frelinghuysen Arboretum	12
United States of America	Fullerton Arboretum	1
United States of America	Gainesway Farm	7
United States of America	Ganna Walska Lotusland	1
United States of America	Gardens at SIUE, The	1
United States of America	Garvan Woodland Gardens	7
United States of America	Grapevine Botanical Gardens at Heritage Park	2
United States of America	Green Bay Botanical Garden	6
United States of America	Green Spring Gardens	11
United States of America	Greenwood Gardens	11
United States of America	Henry Schmieder Arboretum	9
United States of America	Hershey Gardens	4
United States of America	Hidden Lake Gardens	8
United States of America	Holden Arboretum, The	10
United States of America	Hoyt Arboretum	22
United States of America	Jackson's Garden of Union College	1
United States of America	JC Raulston Arboretum	33
United States of America	Jensen-Olson Arboretum	1
United States of America	Lady Bird Johnson Wildflower Center	1
United States of America	Landis Arboretum	6

United States of America	Lauritzen Gardens	7
United States of America	Lewis Ginter Botanical Garden	16
United States of America	Longwood Gardens	23
United States of America	Los Angeles County Arboretum and Botanic Garden	6
United States of America	Matthaei Botanical Gardens & Nichols Arboretum	1
United States of America	Maymont Foundation	3
United States of America	Meadowlark Botanical Gardens	11
United States of America	Mercer Botanic Gardens	10
United States of America	Minnesota Landscape Arboretum	5
United States of America	Missouri Botanical Garden	16
United States of America	Missouri State Arboretum	2
United States of America	Moore Farms Botanical Garden	21
United States of America	Morris Arboretum, The	22
United States of America	Morton Arboretum, The	17
United States of America	Mount Auburn Cemetery	13
United States of America	Mountain Top Arboretum	3
United States of America	Museum of Life + Science Magic Wings Butterfly House	1
United States of America	National Plant Germplasm System - USDA-ARS-NGRL	16
United States of America	National Tropical Botanical Garden	1
United States of America	Nebraska Statewide Arboretum	5
United States of America	New England Wild Flower Society - Garden in the Woods	4

United States of America	New York Botanical Garden, The	23
United States of America	Norfolk Botanical Garden	19
United States of America	North Carolina Arboretum, The	12
United States of America	Oklahoma City Zoo and Botanical Garden	4
United States of America	Peavy Arboretum	1
United States of America	Polly Hill Arboretum, The	18
United States of America	Purdue Arboretum, The	7
United States of America	Quarryhill Botanical Garden	10
United States of America	Queens Botanical Garden	7
United States of America	Red Butte Garden and Arboretum	3
United States of America	Reiman Gardens	3
United States of America	Rhododendron Species Foundation and Botanical Garden	2
United States of America	Rio Grande Botanic Garden	3
United States of America	San Diego Botanic Garden	1
United States of America	San Francisco Botanical Garden	10
United States of America	Sarah P. Duke Gardens	24
United States of America	Scott Arboretum of Swarthmore College, The	22
United States of America	Seeds of Success (SOS)	1
United States of America	Sister Mary Grace Burns Arboretum	6
United States of America	Smith-Gilbert Gardens	9
United States of America	Smithsonian Gardens - Tree Collection	3

United States of America	Smithsonian National Zoological Park	3
United States of America	Spring Grove Cemetery and Arboretum	10
United States of America	State Arboretum of Virginia (Orland E. White Arboretum)	5
United States of America	State Botanical Garden of Georgia, The	18
United States of America	State Botanical Garden of Kentucky	1
United States of America	Taltree Arboretum & Gardens	5
United States of America	Toledo Botanical Garden	8
United States of America	Trees Atlanta	3
United States of America	Tyler Arboretum	16
United States of America	United States National Arboretum	33
United States of America	University of Alabama Arboretum	2
United States of America	University of California Botanical Garden at Berkeley	19
United States of America	University of Delaware Botanic Gardens	19
United States of America	University of Idaho Arboretum & Botanical Garden	5
United States of America	University of Washington Botanic Gardens	21
United States of America	Vanderbilt University Arboretum	3
United States of America	W. J. Beal Botanical Garden	15
United States of America	Waimea Valley Arboretum and Botanical Garden	1
United States of America	Waugh Arboretum	8
United States of America	Willowwood Arboretum	17
United States of America	Yew Dell Botanical Gardens	11

## Appendix C

## BGCI COLLECTIONS SURVEY: ACCESSION STATISTICS

Genus	Specific Epithet	Accessions	Wild Collected Accessions	Unique Wild Collected Accessions
× <i>Sycoparrotia</i>	<i>semidecidua</i>	53	0	0
<i>Corylopsis</i>	<i>bretschneideri</i>	1	0	0
<i>Corylopsis</i>	<i>glaucophylla</i>	1	0	0
<i>Corylopsis</i>	<i>alnifolia</i>	2	0	0
<i>Corylopsis</i>	<i>wilsonii</i>	4	0	0
<i>Corylopsis</i>	<i>hypoglauca</i>	4	4	4
<i>Corylopsis</i>	<i>coreana</i>	8	1	1
<i>Corylopsis</i>	<i>himalayana</i>	10	0	0
<i>Corylopsis</i>	<i>multiflora</i>	11	1	1
<i>Corylopsis</i>	<i>glandulifera</i>	12	4	4
<i>Corylopsis</i>	<i>platypetala</i>	26	0	0
<i>Corylopsis</i>	<i>gotoana</i>	26	4	4
<i>Corylopsis</i>	sp.	28	9	6
<i>Corylopsis</i>	<i>wilmottiae</i>	37	9	3
<i>Corylopsis</i>	<i>veitchiana</i>	37	1	1
<i>Corylopsis</i>	<i>glabrescens</i>	105	16	13
<i>Corylopsis</i>	<i>pauciflora</i>	103	4	4
<i>Corylopsis</i>	<i>spicata</i>	155	4	3
<i>Corylopsis</i>	<i>sinensis</i>	199	48	25
<i>Disanthus</i>	<i>ovatifolius</i>	3	2	2
<i>Disanthus</i>	<i>cercidifolius</i>	65	4	4
<i>Distylium</i>	<i>chinense</i>	1	0	0
<i>Distylium</i>	<i>lepidotum</i>	2	2	1
<i>Distylium</i>	<i>buxifolium</i>	4	0	0
<i>Distylium</i>	<i>myricoides</i>	39	3	2
<i>Distylium</i>	<i>racemosum</i>	79	13	6
<i>Distylium</i>	sp.	119	1	1
<i>Exbucklandia</i>	<i>tonkinensis</i>	1	1	1
<i>Exbucklandia</i>	<i>populnea</i>	11	8	8
<i>Fortunearia</i>	<i>sinensis</i>	19	6	6
<i>Fothergilla</i>	<i>arkansana</i>	1	1	1

<i>Fothergilla</i>	<i>monticola</i>	2	0	0
<i>Fothergilla</i>	sp.	63	12	12
<i>Fothergilla</i>	<i>major</i>	387	84	30
<i>Fothergilla</i>	× <i>intermedia</i>	342	0	0
<i>Fothergilla</i>	<i>gardenii</i>	443	63	10
<i>Hamamelis</i>	<i>macrophylla</i>	3	0	0
<i>Hamamelis</i>	<i>mexicana</i>	10	4	2
<i>Hamamelis</i>	<i>ovalis</i>	37	10	8
<i>Hamamelis</i>	sp.	196	3	2
<i>Hamamelis</i>	<i>japonica</i>	208	26	36
<i>Hamamelis</i>	<i>mollis</i>	354	9	7
<i>Hamamelis</i>	<i>vernalis</i>	573	53	19
<i>Hamamelis</i>	<i>virginiana</i>	848	106	27
<i>Hamamelis</i>	× <i>intermedia</i>	1529	0	0
<i>Loropetalum</i>	<i>subcordatum</i>	1	1	1
<i>Loropetalum</i>	<i>chinense</i>	220	17	9
<i>Matudaea</i>	<i>trinervia</i>	6	3	1
<i>Molinadendron</i>	<i>sinaloense</i>	10	1	1
<i>Mytilaria</i>	<i>laosensis</i>	2	0	0
<i>Neostrearia</i>	<i>fleckeri</i>	2	0	0
<i>Noahdendron</i>	<i>nicholasii</i>	1	0	0
<i>Parrotia</i>	<i>subaequalis</i>	45	3	3
<i>Parrotia</i>	<i>persica</i>	425	15	8
<i>Parrotiopsis</i>	sp.	1	0	0
<i>Parrotiopsis</i>	<i>jacquemontiana</i>	67	8	5
<i>Rhodoleia</i>	<i>parvipetala</i>	1	0	0
<i>Rhodoleia</i>	<i>henryi</i>	9	1	1
<i>Rhodoleia</i>	<i>championii</i>	9	1	1
<i>Sinowilsonia</i>	<i>henryi</i>	60	10	9
<i>Sycopsis</i>	<i>tutcheri</i>	3	0	0
<i>Sycopsis</i>	<i>sinensis</i>	59	5	2
<i>Trichocladus</i>	<i>Ccrinitus</i>	2	0	0
<i>Trichocladus</i>	<i>grandiflorus</i>	2	0	0
<i>Trichocladus</i>	<i>ellipticus</i>	11	2	2



## Appendix D

### BGCI COLLECTIONS SURVEY: PLANTS LEVEL DATA

Species	Plants	Plants: Wild Provanance	Plants: Named Cultivar	Institutions	Countries
× <i>Sycoparrotia semidecidua</i>	68	0	6	32	8
<i>Corylopsis alnifolia</i>	2	0	0	1	1
<i>Corylopsis bretschneideri</i>	1	0	0	1	1
<i>Corylopsis coreana</i>	10	3	0	7	6
<i>Corylopsis glabrescens</i>	158	19	48	35	9
<i>Corylopsis glandulifera</i>	36	11	0	9	4
<i>Corylopsis glaucophylla</i>	1	0	0	1	1
<i>Corylopsis gotoana</i>	48	5	0	15	7
<i>Corylopsis himalayana</i>	10	0	3	6	5
<i>Corylopsis hypoglauca</i>	5	5	0	3	3
<i>Corylopsis multiflora</i>	19	1	0	8	5
<i>Corylopsis pauciflora</i>	226	14	0	42	12
<i>Corylopsis platypetala</i>	40	0	0	18	9
<i>Corylopsis sinensis</i>	292	70	7	44	12
<i>Corylopsis</i> sp.	46	10	19	15	5
<i>Corylopsis spicata</i>	269	7	20	47	13
<i>Corylopsis veitchiana</i>	66	4	0	18	8
<i>Corylopsis wilmottiae</i>	57	14	2	16	7
<i>Corylopsis wilsonii</i>	4	0	0	3	3
<i>Disanthus cercidifolius</i>	95	4	12	26	8
<i>Disanthus ovatifolius</i>	3	2	0	3	3
<i>Distylium buxifolium</i>	4	0	0	4	3
<i>Distylium chinense</i>	1	0	0	1	1
<i>Distylium lepidotum</i>	2	2	0	2	1
<i>Distylium myricoides</i>	44	3	19	16	10
<i>Distylium racemosum</i>	109	13	35	29	12
<i>Distylium</i> sp.	157	1	107	11	4
<i>Exbucklandia populnea</i>	15	12	0	9	4
<i>Exbucklandia tonkinensis</i>	1	1	0	1	1
<i>Fortunearia sinensis</i>	28	11	0	14	5
<i>Fothergilla</i> × <i>intermedia</i>	835	0	823	28	5

<i>Fothergilla arkansana</i>	1	1	1	1	1
<i>Fothergilla gardenii</i>	1098	120	549	44	10
<i>Fothergilla major</i>	704	168	175	55	14
<i>Fothergilla monticola</i>	2	0	0	2	2
<i>Fothergilla</i> sp.	159	32	114	13	4
<i>Hamamelis</i> × <i>intermedia</i>	2214	0	2163	55	12
<i>Hamamelis japonica</i>	254	47	85	44	13
<i>Hamamelis macrophylla</i>	3	0	0	3	2
<i>Hamamelis mexicana</i>	10	4	0	4	2
<i>Hamamelis mollis</i>	442	23	274	52	14
<i>Hamamelis ovalis</i>	52	17	0	12	2
<i>Hamamelis</i> sp.	238	13	149	34	7
<i>Hamamelis vernalis</i>	910	124	425	50	9
<i>Hamamelis virginiana</i>	1519	238	225	59	12
<i>Loropetalum chinense</i>	574	29	427	38	10
<i>Loropetalum subcordatum</i>	1	1	0	1	1
<i>Matudaea trinervia</i>	9	3	0	3	2
<i>Molinadendron sinaloense</i>	10	1	0	3	2
<i>Mytilaria laosensis</i>	2	0	0	1	1
<i>Neostrearia fleckeri</i>	3	0	0	2	2
<i>Noahdendron nicholasii</i>	2	0	0	1	1
<i>Parrotia persica</i>	859	65	392	63	14
<i>Parrotia subaequalis</i>	51	3	1	25	6
<i>Parrotiopsis jacquemontiana</i>	103	24	0	31	13
<i>Parrotiopsis</i> sp.	1	0	0	1	1
<i>Rhodoleia championii</i>	12	1	0	4	2
<i>Rhodoleia henryi</i>	9	1	8	3	2
<i>Rhodoleia parvipetala</i>	1	0	0	1	1
<i>Sinowilsonia henryi</i>	71	13	0	29	9
<i>Sycopsis sinensis</i>	89	5	0	31	11
<i>Sycopsis tutcheri</i>	3	0	0	3	2
<i>Trichocladus crinitus</i>	3	0	0	1	1
<i>Trichocladus ellipticus</i>	20	3	0	10	5
<i>Trichocladus grandiflorus</i>	3	0	0	1	1

## APPENDIX E

### HAMAMELIS RESOURCES

Source	Description
Lofgren, D. O. (1976). <i>Hamamelis: The plant and its propagation</i> . Newark, DE.	Dissertation detailing the various methods and outcomes of propagating species within the genus.
Duckstein, S. M., & Stintzing, F. C. (August 01, 2011). Investigation on the phenolic constituents in <i>Hamamelis virginiana</i> leaves by HPLC-DAD and LC-MS/MS. <i>Analytical and Bioanalytical Chemistry</i> , 401, 2, 677-688.	Peer reviewed article on the phenolic composition of extracts taken from <i>Hamamelis virginiana</i> leaves.
Xie, L., Yi, T. S., Li, R., Li, D. Z., & Wen, J. (January 01, 2010). Evolution and biogeographic diversification of the witch-hazel genus ( <i>Hamamelis</i> L., Hamamelidaceae) in the Northern Hemisphere. <i>Molecular Phylogenetics and Evolution</i> , 56, 2, 675-89.	A comparison of the relationships between Asian and North American species within <i>Hamamelis</i> using phylogenetics.
Taylor, B. N., Arkebauer, R., Bao, K., Bray, N., Gibson, R., Lavenhar, S., Liao, W., Terlizzi, K. P. (January 01, 2017). Growth and physiology of a dominant understory shrub, <i>Hamamelis virginiana</i> , following canopy disturbance in a temperate hardwood forest. <i>Canadian Journal of Forest Research</i> , 47, 2, 193-202.	A peer-reviewed article looking at the growth of <i>Hamamelis virginiana</i> after a disturbance in a forest.
Touriño, S., Lizárraga, D., Carreras, A., Lorenzo, S., Ugartondo, V., Mitjans, M., Vinardell, M. P., Torres, J. L. (January 01, 2008). Highly galloylated tannin fractions from witch hazel ( <i>Hamamelis virginiana</i> ) bark: electron transfer capacity, in vitro antioxidant activity, and effects on skin-related cells. <i>Chemical Research in Toxicology</i> , 21, 3, 696-704.	A peer-reviewed article investigating the ability of phenolic extracts from <i>Hamamelis</i> to combat free radicals.

Nuffer, B. (January 01, 2006). Witch Hazel ( <i>Hamamelis virginiana</i> ). <i>New York State Conservationist</i> , 61, 2.)	A short article describing the cultural and aesthetic qualities of <i>Hamamelis virginiana</i> .
Faivre, C., Ghedira, K., Goetz, P., & Jeune, R. (January 01, 2009). <i>Hamamelis virginiana</i> L. (Hamamelidaceae). <i>Phytothérapie</i> , 7, 4, 215-220.	Discussing the pharmacological effect of <i>Hamamelis virginiana</i> .
Small, E., & Catling, P. M. (1999). <i>Canadian medicinal crops</i> . Ottawa: NRC Research Press.	Medicinal plants native to Canada, including <i>Hamamelis virginiana</i> .
Zilis, M. R. (1979). <i>In vitro embryo and tissue culture studies in the woody plant genera, Viburnum and Hamamelis</i> .	Manuscript investigating propagation methods of woody plants including the genus <i>Hamamelis</i> .
Lane, C. (2005). <i>Witch hazels</i> . Portland: Timber Press [in association with] Royal Horticultural Society.	A resource on the horticultural merits of the genus <i>Hamamelis</i> .
Allen, T. F. (1870). <i>The medical herbarium: A collection of dried samples of medicinal plants</i> .	A collection of twenty herbarium vouchers from 1870, including one voucher of <i>Hamamelis virginiana</i> .
Brown, R., & Abel, C. (1818). <i>Characters and descriptions of three new species of plants found in China by Clarke Abel: Selected from a small collection of specimens: the only part of his herbarium that escaped the wreck of the Alceste</i> . London: Strahan.	A reprint of the narrative of Clarke Abel including the discovery of <i>Hamamelis chinensis</i> ( <i>Loropetalum chinense</i> ).
Applequist, W., William L. Brown Center for Plant Genetic Resources, & American Botanical Council. (2006). <i>The identification of medicinal plants: A handbook of the morphology of botanicals in commerce</i> . St. Louis, Mo: Missouri Botanical Garden.	This was a collaborative publication describing the identifying traits of plants used in trade.

<p>Core, E. L., &amp; Ammons, N. P. (2012). <i>Woody Plants in Winter: A Manual of Common Trees and Shrubs in Winter in the Northeastern United States and Southeastern Canada</i>. Morgantown: West Virginia University Press.</p>	<p><i>Hamamelis</i> is included in this resource which focuses on the identification of trees and shrubs in the winter.</p>
<p>De Steven, D. (1982). Seed Production and Seed Mortality in a Temperate Forest Shrub (Witch- Hazel, <i>Hamamelis Virginiana</i>). <i>Journal of Ecology</i>, 70(2), 437-443. doi:10.2307/2259913</p>	<p>Research into the reproduction rates of <i>Hamamelis virginiana</i>.</p>