

## Development of a DNA Library for Native Hawaiian Plants<sup>1</sup>

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**ABSTRACT:** The native Hawaiian flora is under severe stress because of habitat loss and effects of invasive plants and animals introduced into the ecosystem. These factors are threatening to push many of the endemic species to extinction. In an effort to provide a broad genetic base from which research projects on native species may be initiated, DNA was isolated from endemic and indigenous species from Hawai'i, Kaua'i, Lāna'i, Maui, Moloka'i, and O'ahu and included in a newly created Native Hawaiian Plants DNA Library. DNA accession numbers and collection information are presented for 206 species representing 75 families and 128 genera.

**RENOWNED HAWAIIAN BOTANIST** Otto Degener frequently sent specimens of Hawaiian plants to herbarium curators throughout the world from 1960 on into the 1980s, often accompanied by literature concerning destruction of the flora, with the decree "Save the Hawaiian Flora, at least in the herbaria of the world!" The crisis concerning the flora has intensified in the years since, with the number of species on the U.S. Fish and Wildlife register of endangered or threatened Hawaiian plants now listing 198 taxa, 66 of which are extremely rare (fewer than 10 plants or limited to a single population) and 11 are very likely extinct. Greater than one-third of all the endangered or threatened plants in the United States listed on the register are found in Hawai'i, a land area of only 16,800 km<sup>2</sup> (6500 mi<sup>2</sup>), making Hawai'i the "endangered species capital of the nation" (Royte 1995). In addition to the species currently listed, there are 83 proposed endangered taxa, 10 candidate taxa, and 293 species of concern, underscoring the crisis that exists for the native Hawaiian flora.

Causes for this widespread destruction of Hawaiian endemic biodiversity are manifold (Howarth et al. 1988, Cuddihy and Stone 1990). Agricultural efforts have cleared large tracts of native wetlands, rain forests, and dry forests for farming and grazing. Alien plants arrived inadvertently or were specifically planted to "improve" the native flora for grazing, a potential timber industry, provide cover for erosion control, or as ornamentals that subsequently escaped into the wild. Animals that have been brought purposely or inadvertently to the Islands, such as the feral pigs, goats, deer, rats, and insects, have also severely impacted various ecosystems by their herbivory (grazing, digging up roots, eating flowers and fruits, altering plant-pollinator associations, etc.). A secondary impact of this rampant habitat loss or modification is that following the extinction of numerous birds and insects, additional plants are threatened, or even extinct, because of the loss of their natural pollinators.

Since 1992, an effort has been under way to assemble a DNA library of native Hawaiian plants. The purpose of this effort has been three-fold: to preserve genetic material from plants in a diminishing flora, to obtain DNA from plants in remote regions of the Islands that are infrequently collected, and to provide a basis from which genetic studies on Hawaiian species can be initiated. We report here 814 accessions of isolated DNA from 29 species of ferns and 177 species of flowering

<sup>1</sup> Manuscript accepted 9 November 1995.

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plants, representing 128 genera and 75 families. As such, this work represents nearly one-fifth of the extant species found in the native Hawaiian flora (Wagner et al. 1990, Wagner 1995). Most of the collections were from the islands of Hawai'i and O'ahu, although collections from Kaua'i, Lāna'i, Moloka'i, and Maui were also made.

#### MATERIALS AND METHODS

Plants were collected in the field and stored in self-sealing plastic bags at 4°C until processed. Vouchers for plants collected by us have been deposited at B. P. Bishop Museum (BISH); those plants collected for us by others have been deposited at the collector's discretion.

Isolation of total cellular DNA was done using the CTAB extraction procedure of Doyle and Doyle (1987) with some minor adjustments. Our standard extraction buffer consists of a solution of 2% CTAB (hexadecyltrimethylammonium bromide), 100 mM Tris-HCl (pH 8.0), 1.4 M NaCl, and 20 mM EDTA, with 0.2%  $\beta$ -mercaptoethanol added immediately before use. Although this has worked well for most plant groups, we have found that some species would not extract with this buffer because of the presence of polyphenolic compounds or other secondary metabolites. We therefore have routinely added 2% PVP-40 and 4 mM diethyldithiocarbamic acid to the extraction buffer, which circumvents these problems in most cases. Leaves were ground either in the hot CTAB buffer (65°C) or in liquid nitrogen and then added directly to the hot buffer (for tough, leathery leaves), and incubated for 15 to 60 min at 65°C. Grindate was extracted once with chloroform: isoamyl alcohol (24:1) and spun in a centrifuge (Sorvall RT-6000D) at 3000 rpm for 10 min. The aqueous phase (top) was removed to a new tube, combined with 2/3 volume isopropanol, mixed, incubated at -20°C for at least 30 min to precipitate the DNA, and centrifuged again at 3000 rpm for 5 min to collect the precipitate. The pellet was washed in 76% EtOH, 10 mM ammonium acetate for at least 10 min, spun down

at 3000 rpm for 5 min, drained, and re-suspended in 4 ml TE (10 mM Tris-HCl pH 8.0, 1 mM EDTA). DNA for each species was purified by adding 3.9 g cesium chloride (CsCl) and banded by CsCl/ethidium bromide gradient ultracentrifugation. Bands of DNA were recovered, ethidium bromide was removed with water-saturated butanol, and the DNA was dialyzed against at least three washes in TE. All DNA is being stored at -20°C.

#### RESULTS AND DISCUSSION

During the course of this study, endemic and indigenous plants were specifically sought out to provide the basis of this DNA library (Table 1). However, we have not made a vigorous attempt to collect some plant groups because they are currently under study in other laboratories. Specifically, these include the silversword alliance (Baldwin 1992) and the Hawaiian lobelioids (Givnish et al. 1995). Plant groups that are currently being studied by us have been extensively collected as is evident in Table 1.

Concentrations of the DNA obtained from the plants varied widely and tended to be similar within a group of plants. For example, most pteridophytes, Poaceae, Cyperaceae, Asteraceae, and Viscaceae released large quantity of DNA that banded well during ultracentrifugation. Others, such as Loganiaceae, Lythraceae, Myrsinaceae, and Rubiaceae have yielded very faint bands or no bands at all. Repeated attempts to extract DNA from these problem plants by altering extraction procedures have usually met with similarly poor results. However, all DNAs used from these collections in the course of our own experiments (including those difficult to extract) have performed well in molecular experimentation, including restriction and southern blot analysis, DNA temperature cycling, randomly amplified polymorphic DNAs (RAPDs), and DNA sequencing from amplified products.

Efforts to collect and isolate DNAs from native Hawaiian plants from a diversity of habitats will continue in the future. We en-

TABLE 1

SPECIES FROM WHICH DNA HAS BEEN EXTRACTED (EACH ENTRY REPRESENTS A SEPARATE POPULATION, SOME OF WHICH HAVE BEEN SAMPLED ONLY ONCE, OTHERS SEVERAL TIMES AS INDICATED BY MULTIPLE OR A RANGE OF ACCESSION NUMBERS)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
<b>Pteridophyta</b>				
<b>Adiantaceae</b>				
138	<i>Doryopteris decipiens</i> Sm.	E	So. Kona, H	Morden 1119
<b>Aspleniaceae</b>				
405	<i>Asplenium adiantum-nigrum</i> L.	I	Pōhakuloa (PTA), H	Morden 1313
157	<i>Asplenium nidus</i> L.	I	So. Kona, H	Morden 1128
397	<i>Asplenium trichomanes</i> L.	I	Pōhakuloa (PTA), H	Morden 1305
<b>Blechnaceae</b>				
604	<i>Sadleria souleyetiana</i> (Gaud.) T. Moore	E	Poamoho Ridge, O	Morden 1231
478	<i>Sadleria unisora</i> (Baker) Robinson	E	Wahiawa Stream, K	Morden 1361
<b>Cyatheaceae</b>				
620–622	<i>Cibotium chamissoi</i> Kaulf.	E	'Aiea Ridge, O	Motley 1373
626–628	<i>Cibotium chamissoi</i> Kaulf.	E	'Aiea Ridge, O	Motley 1395
632–634	<i>Cibotium glaucum</i> (Sm.) Hook. & Arnott	E	'Aiea Ridge, O	Motley 1401
614–616	<i>Cibotium menziesii</i> Hook.	E	'Aiea Ridge, O	Motley 1367
623–625	<i>Cibotium menziesii</i> Hook.	E	'Aiea Ridge, O	Motley 1392
629–631	<i>Cibotium glaucum</i> × <i>menziesii</i>	E	'Aiea Ridge, O	Motley 1398
617–619	<i>Cibotium menziesii</i> × <i>chamissoi</i>	E	'Aiea Ridge, O	Motley 1370
<b>Dryopteridaceae</b>				
601	<i>Cyrtomium caryotideum</i> Presl	I	Pu'u Huluhulu, H	Morden 1344
392	<i>Dryopteris wallichiana</i> (Spreng.) Hyl.	I	Pōhakuloa (PTA), H	Morden 1300
602	<i>Elaphoglossum hirtum</i> (Sw.) C. Chr.	E	Pu'u Huluhulu, H	Morden 1345
132	<i>Nephrolepis exaltata</i> (L.) Schott	E	So. Kona, H	Morden 1113
167	<i>Tectaria gaudichaudii</i> (Mett.) Maxon	E	Mānoa Cliffs, O	Morden 1137
<b>Gleicheniaceae</b>				
366	<i>Dicranopteris linearis</i> (N. L. Burn) Underw.	I	Poamoho Ridge, O	Morden 1243
364	<i>Diplopterygium pinnatum</i> (Kunze) Nakai	I	Poamoho Ridge, O	Morden 1240
<b>Grammitidaceae</b>				
369	<i>Adenophorus pinnatifidus</i> Gaud.	E	Poamoho Ridge, O	Morden 1248
353	<i>Adenophorus tamariscinus</i> (Kaulf.) Hook. & Grev.	E	Poamoho Ridge, O	Morden 1223
381	<i>Grammitis baldwinii</i> (Baker) Copel.	E	Poamoho Ridge, O	Morden 1268
<b>Hypolepidaceae</b>				
390	<i>Pteridium decompositum</i> Gaud.	E	Pōhakuloa (PTA), H	Morden 1298
<b>Lindsaeaceae</b>				
368	<i>Odontosoria chinensis</i> (L.) J. Sm.	I	Poamoho Ridge, O	Morden 1246
<b>Lycopodiaceae</b>				
367	<i>Huperzia erubescens</i> (Brack.) Holub.	I	Poamoho Ridge, O	Morden 1245
361	<i>Palhinhaea cernua</i> (L.) Franco & Carv. Vasc.	I	Poamoho Ridge, O	Morden 1234
<b>Marsileaceae</b>				
334	<i>Marsilea villosa</i> Kaulf.	E	Queen's Beach, O	Morden 1271
<b>Polypodiaceae</b>				
116	<i>Lepisorus thunbergianus</i> (Kaulf.) Ching	I	So. Kona, H	Morden 1097
580	<i>Polypodium pellucidum</i> Kaulf.	E	Pōhakuloa (PTA), H	Morden 1337
<b>Psilotaceae</b>				
112	<i>Psilotum nudum</i> (L.) Beauv.	I	So. Kona, H	Morden 1093
<b>Pteridaceae</b>				
393	<i>Pteris cretica</i> L.	I	Pōhakuloa (PTA), H	Morden 1301
<b>Sinopteridaceae</b>				
400	<i>Pellaea ternifolia</i> (Cav.) Link	I	Pōhakuloa (PTA), H	Morden 1308
<b>Monocotyledoneae</b>				
<b>Agavaceae</b>				
111	<i>Pleomele hawaiiensis</i> Degener & I. Degener	E	So. Kona, H	Morden 1092

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
Cyperaceae				
398	<i>Carex wahuensis</i> C. A. Mey. ssp. <i>rubiginosa</i> (R. Krauss) T. Koyama	E	Pōhakuloa (PTA), H	Morden 1306
915	<i>Cyperus laevigatus</i> L.	I	Princeville, K	Morden 1415
347	<i>Fimbristylis cymosa</i> R. Br.	I	Queen's Beach, O	Morden 1288
371	<i>Machaerina angustifolia</i> (Gaud.) T. Koyama	I	Poamoho Ridge, O	Morden 1253
378	<i>Machaerina marscooides</i> (Gaud.) J. Kern ssp. <i>meyenii</i> (Kunth) T. Koyama	E	Poamoho Ridge, O	Morden 1263
113	<i>Mariscus fauriei</i> (Kükenth.) T. Koyama	E	So. Kona, H	Morden 1094
521	<i>Mariscus hillebrandii</i> (Boeck.) T. Koyama	E	Pu'u Nohonaohae, H	Morden 1402
Orchidaceae				
297	<i>Anoectochilus sandwicensis</i> Lindl.	E	Mt. Ka'ala, O	Morden 1210
296	<i>Liparis hawaiiensis</i> H. Mann	E	Mt. Ka'ala, O	Morden 1209
Pandanaaceae				
609	<i>Freycinetia arborea</i> Gaud.	I	Poamoho Ridge, O	Morden 1264
Poaceae				
200	<i>Chrysopogon aciculatus</i> (Retz.) Trin.	I	Bellows AFB, O	Morden 1176
169	<i>Deschampsia nubigena</i> Hillebr.	E	Mauna Loa, H	Morden 1150
414	<i>Deschampsia nubigena</i> Hillebr.	E	Mauna Kea, H	Morden 1321
351	<i>Dichantherium koolauensis</i> (St. John & Hosaka) C. A. Clark & Gould	E	Ko'olau Mts., O	Morden 1244
263	<i>Digitaria setigera</i> Roth	I	Līhu'e, K	Morden 1187
285	<i>Eragrostis atropioides</i> Hillebr.	E	Hāpuna, H	Morden 1198
407	<i>Eragrostis atropioides</i> Hillebr.	E	Pōhakuloa (PTA), H	Morden 1315A
409	<i>Eragrostis leptophylla</i> Hitchc.	E	Pōhakuloa (PTA), H	Morden 1316
350	<i>Eragrostis variabilis</i> (Gaud.) Steud.	E	Queen's Beach, O	Palmer sn.
189	<i>Heteropogon contortus</i> (L.) P. Beauv. ex Roem. & Schult.	I	Bellows AFB, O	Morden 1164
356	<i>Isachne distichophylla</i> Munro ex Hillebr.	E	Poamoho Ridge, O	Morden 1227
922	<i>Isachne distichophylla</i> Munro ex Hillebr.	E	Tantalus, O	Motley 1577
337	<i>Panicum fauriei</i> Hitchc. var. <i>fauriei</i>	E	Queen's Beach, O	Morden 1275
567	<i>Panicum tenuifolium</i> Hook. & Arnott	E	Pōhakuloa (PTA), H	Morden 1333
201	<i>Panicum torridum</i> Gaud.	E	Kula, M	Morden 1177
344	<i>Panicum torridum</i> Gaud.	E	Queen's Beach, O	Morden 1283
199	<i>Paspalum scrobiculatum</i> L.	I	Bellows AFB, O	Morden 1175
272	<i>Sporobolus virginicus</i> (L.) Kunth	I	Kamala Bay, O	Morden 1194
411	<i>Trisetum glomeratum</i> (Kunth) Trin.	E	Pōhakuloa (PTA), H	Morden 1318
Smilacaceae				
354	<i>Smilax melastomifolia</i> Sm.	E	Poamoho Ridge, O	Morden 1224
Dicotyledoneae				
Aizoaceae				
292	<i>Sesuvium portulacastrum</i> (L.) L.	I	Mahai'ula Beach, H	Morden 1205
348	<i>Sesuvium portulacastrum</i> (L.) L.	I	Queen's Beach, O	Morden 1289
Amaranthaceae				
115	<i>Nototrichium sandwicense</i> (A. Gray) Hillebr.	E	So. Kona, H	Morden 1096
Apocynaceae				
377	<i>Alyxia oliviformis</i> Gaud.	E	Poamoho Ridge, O	Morden 1262
612	<i>Ochrosia kilaueaensis</i> St. John	E	Volcano, H	Motley 1541
287	<i>Rauwolfia sandwicensis</i> A. DC	E	Waimea, H	Morden 1200
Araliaceae				
355	<i>Cheirodendron platyphyllum</i> (Hook. & Arnott) Seem.	E	Poamoho Ridge, O	Morden 1226
Asteraceae				
321	<i>Artemisia australis</i> Less.	E	Hawai'i Kai, O	Morden 1217
608	<i>Bidens macrocarpa</i> (A. Gray) Sherff	E	Poamoho Ridge, O	Morden 1261

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
384	<i>Bidens menziesii</i> (A. Gray) Sherff ssp. <i>filiformis</i> (Sherff) Ganders & Nagata	E	Pōhakuoa (PTA), H	Morden 1292
544	<i>Bidens micrantha</i> Gaud. ssp. <i>ctenophylla</i> (Sherff) Nagata & Ganders	E	Kailua, Kona, H	Morden 1413
433–443	<i>Dubautia ciliolata</i> (DC) D. Keck ssp. <i>ciliolata</i>	E	Mauna Loa, H	Motley 1481–1491
457	<i>Dubautia ciliolata</i> (DC) D. Keck ssp. <i>glutinosa</i> G. Carr	E	Mauna Kea, H	Motley 1526
518	<i>Dubautia imbricata</i> St. John & G. Carr	E	Wahiawa Stream, K	G. Carr 1411
486–493	<i>Dubautia imbricata</i> St. John & G. Carr	E	Wahiawa Stream, K	Morden 1369–1376
485	<i>Dubautia laxa</i> Hook. & Arnott	E	Wahiawa Stream, K	Morden 1368
374	<i>Dubautia laxa</i> Hook. & Arnott var. <i>bryanii</i> (Sherff) G. Carr	E	Poamoho Ridge, O	Morden 1257
507–517	<i>Dubautia raillardoides</i> Hillebr.	E	Wahiawa Stream, K	Morden 1390–1400
422–432	<i>Dubautia scabra</i> (DC) D. Keck	E	Mauna Loa, H	Motley 1502–1512
459	<i>Dubautia scabra</i> (DC) D. Keck	E	Waikamoi Stream, M	Carr 953 <sup>c</sup>
460	<i>Dubautia scabra</i> (DC) D. Keck	E	Ha'alelepa'akai Rdg, L	Motley 1529 <sup>c</sup>
461	<i>Dubautia scabra</i> (DC) D. Keck	E	So. Kona, H	Witter 639 <sup>c</sup>
458	<i>Dubautia scabra</i> (DC) D. Keck	E	Olinda Flume, M	Baldwin 778 <sup>c</sup>
494–506	<i>Dubautia laxa</i> × <i>raillardoides</i>	E	Wahiawa Stream, K	Morden 1377–1389
444–456	<i>Dubautia scabra</i> × <i>ciliolata</i>	E	Mauna Loa, H	Motley 1513–1525
462	<i>Dubautia scabra</i> × <i>ciliolata</i>	E	Artificial hybrid	Carr 1342 B8 <sup>f</sup>
463–473	<i>Dubautia scabra</i> × <i>ciliolata</i>	E	Mauna Loa, H	Morden 1346–1356
418	<i>Gnaphalium sandwicense</i> Gaud. var. <i>kilaueanum</i> Degener & Sherff	E	Mauna Kea, H	Morden 1325
519	<i>Hesperomannia lydgatei</i> C. Forbes	E	Wahiawa Stream, K	D. Lorence 7703
318–320	<i>Lipochaeta integrifolia</i> (Nutt.) A. Gray	E	Hawai'i Kai, O	Morden 1216
543	<i>Lipochaeta subcordata</i> A. Gray	E	Kailua, Kona, H	Morden 1412
540	<i>Tetramolopium consanguineum</i> (A. Gray) Hillebr.	E	Pōhakuoa, H	Morden 1407
421	<i>Tetramolopium humile</i> (A. Gray) Hillebr. ssp. <i>humile</i>	E	Mauna Kea, H	Morden 1328
Boraginaceae				
339	<i>Heliotropium anomalum</i> Hook. & Arnott	I	Queen's Beach, O	Morden 1277
289	<i>Heliotropium anomalum</i> Hook. & Arnott	I	Kohala, H	Morden 1202
290	<i>Heliotropium curassavicum</i> L.	I	Mahai'ula Beach, H	Morden 1203
Campanulaceae				
483	<i>Cyanea spathulata</i> (Hillebr.) A. Heller ssp. <i>longipetiolata</i> Lammers	E	Wahiawa Stream, K	Morden 1366
372	<i>Lobelia gaudichaudii</i> A. DC	E	Poamoho Ridge, O	Morden 1254
Capparidaceae				
291	<i>Capparis sandwichiana</i> DC	E	Mahai'ula Beach, H	Morden 1204
613	<i>Capparis sandwichiana</i> DC	E	Ka'ena Pt., O	Pang sn.
Caryophyllaceae				
322	<i>Schiedea globosa</i> H. Mann	E	Hawai'i Kai, O	Morden 1218
583	<i>Silene hawaiiensis</i> Sherff	E	Pōhakuoa, H	Morden 1340
419	<i>Silene struthioloides</i> A. Gray	E	Mauna Kea, H	Morden 1326
Celastraceae				
359	<i>Perrottetia sandwicensis</i> A. Gray	E	Poamoho Ridge, O	Morden 1230
Chenopodiaceae				
396	<i>Chenopodium oahuense</i> (Meyen) Aellen	E	Pōhakuoa (PTA), H	Morden 1304

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
Convolvulaceae				
523	<i>Ipomoea indica</i> (J. Burm.) Merr.	I	Pu'u Nohonaohae, H	Morden 1404
Cucurbitaceae				
205	<i>Sicyos hispidus</i> Hillebr.	E	Kula, M	Morden 1181
387	<i>Sicyos anunu</i> (St. John) Telford	E	Pōhakuloa (PTA), H	Morden 1295
520	<i>Sicyos</i> sp. A	E	Pu'u Huluhulu, H	Morden 1401
Droseraceae				
635	<i>Drosera angelica</i> Huds.	I	Wahiawa Bog, K	Motley 1440
Elaeocarpaceae				
358	<i>Elaeocarpus bifidus</i> Hook. & Arnott	E	Poamoho Ridge, O	Morden 1229
Epacridaceae				
402	<i>Styphelia tameiameiae</i> (Cham. & Schlechtend.) F.v. Muell.	I	Pōhakuloa (PTA), H	Morden 1310
Ericaceae				
603	<i>Vaccinium dentatum</i> Sm.	E	Poamoho Ridge, O	Morden 1225
623	<i>Vaccinium dentatum</i> Sm.	E	Tantalus, O	Motley 1578
420	<i>Vaccinium reticulatum</i> Sm.	E	Mauna Kea, H	Morden 1327
579	<i>Vaccinium reticulatum</i> Sm.	E	Pōhakuloa, H	Morden 1336
Euphorbiaceae				
144	<i>Aleurites moluccana</i> (L.) Willd.	P	So. Kona, H	Morden 1124
375	<i>Antidesma platyphyllum</i> H. Mann	E	Poamoho Ridge, O	Morden 1258
133	<i>Antidesma pulvinatum</i> Hillebr.	E	So. Kona, H	Morden 1114
921	<i>Chamaesyce clusiifolia</i> (Hook. & Arnott) Arth.	E	Tantalus, O	Motley 1576
338	<i>Chamaesyce degeneri</i> (Sherff) Croizat & Degener	E	Queen's Beach, O	Morden 1276
403	<i>Chamaesyce olowaluana</i> (Sherff) Croizat & Degener	E	Pōhakuloa (PTA), H	Morden 1311
482	<i>Chamaesyce remyi</i> (A. Gray ex Boiss.) Croizat & Degener	E	Wahiawa Stream, K	Morden 1365
Fabaceae				
569–578, 610	<i>Acacia koa</i> A. Gray	E	Pōhakuloa, H	Morden 1335
273–282	<i>Acacia koaia</i> Hillebr.	E	Waimea, H	Morden 1195
123, 141	<i>Canavalia hawaiiensis</i> Degener, I. Degener & J. Sauer	E	So. Kona, H	Morden 1104
165	<i>Erythrina sandwicensis</i> Degener	E	So. Kona, H	Morden 1135
309	<i>Erythrina sandwicensis</i> Degener	E	Kula, M	Morden sn.
140	<i>Senna gaudichaudii</i> (Hook. & Arnott) H. Irwin & Barneby	I	So. Kona, H	Morden 1121
142	<i>Sophora chrysophylla</i> (Salisb.) Seem.	E	So. Kona, H	Morden 1122
159	<i>Tephrosia purpurea</i> (L.) Pers. var. <i>purpurea</i>	P	So. Kona, H	Morden 1130
916	<i>Vigna marina</i> (J. Burm.) Merr.	I	Princeville, K	Morden 1418
Flacourtiaceae				
163	<i>Xylosma hawaiiense</i> Seem.	E	So. Kona, H	Morden 1134
Geraniaceae				
168	<i>Geranium cuneatum</i> Hook.	E	Mauna Loa, H	Morden 1151
Gesneriaceae				
325	<i>Cyrtandra lysiosepala</i> (A. Gray) C. B. Clarke	E	Pu'u Maka'ala, H	Palmer 595
324	<i>Cyrtandra platyphylla</i> A. Gray	E	Pu'u Maka'ala, H	Palmer 594
326–333	<i>Cyrtandra platyphylla</i> × <i>lysiosepala</i>	E	Pu'u Maka'ala, H	Palmer 596–603
Goodeniaceae				
250–256	<i>Scaevola chamissoniana</i> Gaud.	E	Volcano, H	Howarth 44–50
47–65	<i>Scaevola coriacea</i> Nutt.	E	Waihe'e, M	Goldstein sn.
217, 219, 221–222	<i>Scaevola gaudichaudiana</i> Cham.	E	Lanipō Trail, O	Howarth 7, 11, 13–14

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
224, 230, 231, 234	<i>Scaevola gaudichaudiana</i> Cham.	E	Tantalus, O	Howarth 17, 23, 24, 27
247–248	<i>Scaevola gaudichaudiana</i> Cham.	E	K	Howarth 41– 42
237–238	<i>Scaevola gaudichaudii</i> Hook. & Arnott	E	K	Howarth 31– 32
239–240	<i>Scaevola glabra</i> Hook. & Arnott	E	Alaka'i Swamp, K	Howarth 33– 34
243	<i>Scaevola glabra</i> Hook. & Arnott	E	Alaka'i Swamp, K	Howarth 37
607	<i>Scaevola glabra</i> Hook. & Arnott	E	Poamoho Ridge, O	Morden 1260
178	<i>Scaevola kilaueae</i> Degener	E	Kīlauea, H	Morden 1141
218, 220	<i>Scaevola mollis</i> Hook. & Arnott	E	Lanipō Trail, O	Howarth 10, 12
227, 228, 233, 235	<i>Scaevola mollis</i> Hook. & Arnott	E	Tantalus, O	Howarth 20, 21, 26, 28
236, 241, 242, 244–246	<i>Scaevola procera</i> Hillebr.	E	Alaka'i Swamp, K	Howarth 29, 35, 36, 38, 39, 40
223	<i>Scaevola sericea</i> Vahl	E	'Aiea, O	Howarth 16
66–84	<i>Scaevola sericea</i> Vahl	E	Waihe'e, M	Beach sn.
85–94	<i>Scaevola sericea</i> Vahl	E	Sandy Beach, O	Beach sn.
95–104	<i>Scaevola sericea</i> Vahl	E	Makapu'u, O	Beach sn.
105–109	<i>Scaevola sericea</i> Vahl	E	Ka'ena Point, O	Heraux sn.
311–316	<i>Scaevola sericea</i> Vahl	E	Ka'ena Point, O	Heraux sn.
215–216	<i>Scaevola gaudichaudiana</i> × <i>mollis</i>	E	Lanipō Trail, O	Howarth 5–6
225–226, 229, 232	<i>Scaevola gaudichaudiana</i> × <i>mollis</i>	E	Tantalus, O	Howarth 18– 19, 22, 25
249	<i>Scaevola gaudichaudiana</i> × <i>mollis</i>	E	O	Howarth 43
257	<i>Scaevola gaudichaudiana</i> × <i>mollis</i>	E	Castle Trail, O	Howarth 51
Hydrangeaceae				
376	<i>Broussaisia arguta</i> Gaud.	E	Poamoho Ridge, O	Morden 1259
920	<i>Broussaisia arguta</i> Gaud.	E	Tantalus, O	Motley 1575
Lamiaceae				
525–539	<i>Haplostachys haplostachya</i> (A. Gray) St. John	E	Pōhakuloa (PTA), H	Morden 1406
545–565	<i>Haplostachys haplostachya</i> (A. Gray) St. John	E	Pōhakuloa (PTA), H	Morden 1414
584–599	<i>Haplostachys haplostachya</i> (A. Gray) St. John	E	Pōhakuloa (PTA), H	Morden 1341
605	<i>Phyllostegia grandiflora</i> (Gaud.) Benth.	E	Poamoho Ridge, O	Morden 1239
160	<i>Plectranthus parviflorus</i> Willd.	I	So. Kona, H	Morden 1131
416	<i>Stenogyne microphylla</i> Benth.	E	Mauna Kea, H	Morden 1323
417	<i>Stenogyne rugosa</i> Benth.	E	Mauna Kea, H	Morden 1324
Loganiaceae				
638–640	<i>Labordia cyrtandrae</i> (Baill.) St. John	E	Schofield, O	Motley 1122, 1130, 1131
641–644	<i>Labordia degeneri</i> Sherff	E	Hanakoa, K	Motley 1087– 1091
645–647	<i>Labordia degeneri</i> Sherff	E	Kōke'e, K	Motley 1404– 1406
648–655	<i>Labordia degeneri</i> Sherff	E	Alaka'i Swamp, K	Motley 1411– 1418
656–657	<i>Labordia degeneri</i> Sherff	E	Wahiawa Bog, K	Motley 1441– 1442
658–660	<i>Labordia fagraeoides</i> Gaud.	E	Poamoho, O	Motley 1094– 1096
661	<i>Labordia hedyosmifolia</i> Baill.	E	Volcano, H	Motley 1111
662–667	<i>Labordia hedyosmifolia</i> Baill.	E	Pēpē'ōpae Bog, Mo	Motley 1145– 1148

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
668–689	<i>Labordia hedyosmifolia</i> Baill.	E	Pu'u Kukui, M	Motley 1163–1180, 1346–1349
691–692	<i>Labordia hedyosmifolia</i> Baill.	E	East M	Motley 1329, 1407
693–697	<i>Labordia hedyosmifolia</i> Baill.	E	Hana'ula, M	Motley 1334–1338
690, 698–708	<i>Labordia hedyosmifolia</i> Baill.	E	Lāna'i Hale, L	Motley 1286, 1294, 1450–1459
709–718	<i>Labordia hedyosmifolia</i> Baill.	E	Kūlani Prison, H	Motley 1471–1480
719–727	<i>Labordia hedyosmifolia</i> Baill.	E	Pu'u Maka'ala, H	Motley 1481–1489
728–734	<i>Labordia hedyosmifolia</i> Baill.	E	Volcano, H	Motley 1532–1538
740–741	<i>Labordia helleri</i> Sherff	E	Awa'awapuhi, K	Motley 1092, 1264
742–743	<i>Labordia helleri</i> Sherff	E	Nu'alolo, K	Motley 1266, 1270
744, 746–748	<i>Labordia hirtella</i> H. Mann	E	East M	Motley 1404–1406, 1320
749–755	<i>Labordia hirtella</i> H. Mann	E	Hana'ula, M	Motley 1339–1343
756–760	<i>Labordia hirtella</i> H. Mann	E	Kewalo Gulch, Mo	Motley 1140, 1141, 1150, 1252, 1254
761–762	<i>Labordia hirtella</i> H. Mann	E	Pu'u Kukui, M	Motley 1182, 1345
763–765	<i>Labordia hirtella</i> H. Mann	E	Wahiawa Bog, K	Motley 1429, 1435, 1445
766–775	<i>Labordia hosakana</i> (Sherff) W. L. Wagner, Herbst & Sohmer	E	'Aiea Ridge, O	Motley 1186–1195
776–780	<i>Labordia kaalae</i> C. Forbes	E	Palikea, O	Motley 1200–1203, 1206
781–795	<i>Labordia kaalae</i> C. Forbes	E	Pahole Gulch, O	Motley 1231–1245
796–800	<i>Labordia lydgatei</i> C. Forbes	E	Wahiawa Bog, K	Motley 1425, 1426, 1432, 1444, 1446
802	<i>Labordia pumila</i> (Hillebr.) Skottsb.	E	Alaka'i Swamp, K	Motley 1273
803–806	<i>Labordia sessilis</i> A. Gray	E	Poamoho, O	Motley 1093, 1097, 1098, 1150
807–814	<i>Labordia tinifolia</i> A. Gray var. <i>tinifolia</i>	E	Hawai'i Loa, O	Motley 1220, 1222–1226, 1229, 1230
815–818	<i>Labordia tinifolia</i> A. Gray var. <i>tinifolia</i>	E	Wai'anae Kai, O	Motley 1363–1366
819–828	<i>Labordia tinifolia</i> A. Gray var. <i>tinifolia</i>	E	Tantalus, O	Motley 1380–1389
829–830	<i>Labordia tinifolia</i> A. Gray var. <i>tinifolia</i>	E	Wai'anae, O	Motley 1390–1391
831	<i>Labordia tinifolia</i> A. Gray var. <i>tinifolia</i>	E	Pu'u Kolo, K	Motley 1410
832–836	<i>Labordia tinifolia</i> A. Gray var. <i>wahiawaensis</i> St. John	E	Wahiawa Bog, K	Motley 1427, 1428, 1431, 1437, 1438
837–838	<i>Labordia triflora</i> Hillebr.	E	Kua Gulch, Mo	Motley 1149, 1258



TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
839–860	<i>Labordia venosa</i> Sherff	E	East M	Motley 1307–1328
861–864	<i>Labordia venosa</i> Sherff	E	Hana‘ula, M	Motley 1330–1333
866	<i>Labordia venosa</i> Sherff	E	East M	Motley 1344
867–873	<i>Labordia waialealae</i> Wawra	E	Alaka‘i Swamp, K	Motley 1074, 1075, 1080–1082, 1087, 1279
874–879	<i>Labordia waiolani</i> Wawra	E	Mt. Ka‘ala, O	Motley 1101, 1106–1110
880–889	<i>Labordia waiolani</i> Wawra	E	Pēpē‘ōpae Bog, Mo	Motley 1135–1139, 1142, 1143, 1259–1261
890	<i>Labordia waiolani</i> Wawra	E	Palikea, O	Motley 1215
735–739, 891–896	<i>Labordia waiolani</i> Wawra	E	Lāna‘i Hale, L	Motley 1290–1292, 1296, 1301, 1460–1464
801	<i>Labordia lydgatei</i> × <i>hirtella</i>	E	Wahiawa Bog, K	Motley 1433
Lythraceae 391	<i>Lythrum maritimum</i> Kunth	I	Pōhakuloa (PTA), H	Morden 1299
Malvaceae 897	<i>Abutilon eremitopetalum</i> Caum	E	Waimea Falls, O <sup>d</sup>	Motley 1377
898	<i>Abutilon incanum</i> (Link) Sweet	I	Queen’s Beach, O	Motley 1449
899	<i>Abutilon menziesii</i> Seem.	E	Waimea Falls, O <sup>d</sup>	Motley 1376
900	<i>Abutilon sandwicense</i> (Degener) Christoph.	E	Waimea Falls, O <sup>d</sup>	Motley 1378
283	<i>Kokia drynarioides</i> (Seem.) Lewton	E	Waimea, H	Morden 1196
Myoporaceae 158	<i>Myoporum sandwicense</i> A. Gray	I	So. Kona, H	Morden 1129
288	<i>Myoporum sandwicense</i> A. Gray	I	Waimea, H	Morden 1201
Myrsinaceae 475	<i>Myrsine linearifolia</i> Hosaka	E	Wahiawa Stream, K	Morden 1358
Myrtaceae 39–41	<i>Metrosideros macropus</i> Hook. & Arnott	E	Ko‘olau Mts., O	Aradhya sn.
1–7	<i>Metrosideros polymorpha</i> Gaud.	E	1200 m (4000’) kipuka, H	Cordell sn.
8–14	<i>Metrosideros polymorpha</i> Gaud.	E	1200 m (4000’) 1855 flow, H	Cordell sn.
15–21	<i>Metrosideros polymorpha</i> Gaud.	E	1800 m (6000’) flow, H	Cordell sn.
22–28	<i>Metrosideros polymorpha</i> Gaud.	E	1800 m (6000’) kipuka, H	Cordell sn.
29–35	<i>Metrosideros polymorpha</i> Gaud.	E	1800 m (6000’) 1855 flow, H	Cordell sn.
36–38	<i>Metrosideros rugosa</i> A. Gray	E	Ko‘olau Mts., O	Aradhya sn.
42–46	<i>Metrosideros tremuloides</i> (A. Heller) P. Kunth	E	Ko‘olau Mts., O	Aradhya sn.
477	<i>Metrosideros waialealae</i> (Rock) Rock var. <i>waialealae</i>	E	Wahiawa Stream, K	Morden 1360
Nyctaginaceae 382	<i>Boerhavia herbstii</i> Fosb.	E	Kāne‘ohe, O	Morden 1269
345	<i>Boerhavia repens</i> L.	I	Queen’s Beach, O	Morden 1286
Oleaceae 127	<i>Nestegis sandwicensis</i> (A. Gray) Degener, Degener & Johnson	E	So. Kona, H	Morden 1108
Onagraceae 365	<i>Ludwigia octovalvis</i> (Jacq.) Raven	P	Poamoho Ridge, O	Morden 1241
Papaveraceae 298–305	<i>Argemone glauca</i> (Nutt. ex Prain) Pope	E	Kula, M	Morden 1211

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
901-910	<i>Argemone glauca</i> (Nutt. ex Prain) Pope	E	S. Kona, H	Motley 1353-1362
Piperaceae				
919	<i>Peperomia ellipticibacca</i> C. DC	E	Tantalus, O	Motley 1574
137	<i>Peperomia leptostachya</i> Hook. & Arnott	I	So. Kona, H	Morden 1118
Pittosporaceae				
373	<i>Pittosporum glabrum</i> Hook. & Arnott	E	Poamoho Ridge, O	Morden 1255
164	<i>Pittosporum terminalioides</i> Planch. ex A. Gray	E	So. Kona, H	Morden 1102
Plantaginaceae				
360	<i>Plantago pachyphylla</i> A. Gray	E	Poamoho Ridge, O	Morden 1233
Plumbaginaceae				
323	<i>Plumbago zeylandica</i> L.	I	Hawai'i Kai, O	Morden 1219
Polygonaceae				
389	<i>Rumex giganteus</i> W. T. Aiton	E	Pōhakuloa (PTA), H	Morden 1297
176	<i>Rumex skottsbergii</i> Degener & I. Degener	E	Mauna Loa, H	Morden 1153
Rhamnaceae				
134, 148-156	<i>Colubrina oppositifolia</i> Brongn. ex H. Mann	E	So. Kona, H	Morden 1115
Rosaceae				
404	<i>Osteomeles anthyllidifolia</i> (Sm.) Lindl.	I	Pōhakuloa (PTA), H	Morden 1312
208	<i>Rubus hawaiiensis</i> A. Gray	E	Volcano, H	Gardner sn.
207	<i>Rubus macraei</i> A. Gray	E	Saddle Road, H	Gardner sn.
Rubiaceae				
479	<i>Bohea timonioides</i> (J. D. Hook.) Hillebr.	E	Wahiawa Stream, K	Morden 1362
136	<i>Canthium odoratum</i> (G. Forster) Seem.	I	So. Kona, H	Morden 1117
581	<i>Coprosma ernodeoides</i> A. Gray	E	Pōhakuloa, H	Morden 1338
379	<i>Coprosma longifolia</i> A. Gray	E	Poamoho Ridge, O	Morden 1265
388	<i>Coprosma montana</i> Hillebr.	E	Pōhakuloa (PTA), H	Morden 1296
363	<i>Hedyotis st-johnii</i> Stone & Lane	E	Poamoho Ridge, O	Morden 1238
474	<i>Hedyotis tryblium</i> Herbst & W. L. Wagner	E	Wahiawa Stream, K	Morden 1357
918	<i>Nertera granadensis</i> (L. fil.) Druce	I	Tantalus, O	Motley 1573
Rutaceae				
362, 370	<i>Melicope oahuensis</i> (H Lév.) T. Hartley & B. Stone	E	Poamoho Ridge, O	Morden 1237, 1251
Santalaceae				
286	<i>Santalum ellipticum</i> Gaud.	E	Lapakahi, H	Morden 1199
340	<i>Santalum ellipticum</i> Gaud. var. <i>littorale</i> (Hillebr.) Skottsbo.	E	Makapu'u, O	Morden 1278
135	<i>Santalum paniculatum</i> Hook. & Arnott	E	So. Kona, H	Morden 1116
394	<i>Santalum paniculatum</i> Hook. & Arnott	E	Pōhakuloa (PTA), H	Morden 1302
Sapindaceae				
166	<i>Dodonaea viscosa</i> Jacq.	I	So. Kona, H	Morden 1136
401	<i>Dodonaea viscosa</i> Jacq.	I	Pōhakuloa (PTA), H	Morden 1309
Sapotaceae				
114	<i>Pouteria sandwicensis</i> (A. Gray) Baehni & Degener	E	So. Kona, H	Morden 1095
Solanaceae				
346	<i>Lycium sandwicense</i> A. Gray	I	Queen's Beach, O	Morden 1287
541	<i>Nothocestrum breviflorum</i> A. Gray	E	Kailua, Kona, H	Morden 1410
Thymeliaceae				
606	<i>Wikstroemia oahuensis</i> (A. Gray) Rock	E	Poamoho Ridge, O	Morden 1249
522	<i>Wikstroemia pulcherrima</i> Skottsbo.	E	Waiki'i Ranch, H	Morden 1403
139	<i>Wikstroemia sandwicensis</i> Meisn.	E	So. Kona, H	Morden 1120
Urticaceae				
566	<i>Hesperocnide sandwicensis</i> (Wedd.) Wedd.	E	Pōhakuloa (PTA), H	Morden 1332
582	<i>Hesperocnide sandwicensis</i> (Wedd.) Wedd.	E	Pōhakuloa (PTA), H	Morden 1339
542	<i>Neraudia ovata</i> Gaud.	E	Kailua, Kona, H	Morden 1411

TABLE 1 (continued)

ACCESSION NO.	SPECIES	ORIGIN <sup>a</sup>	LOCATION <sup>b</sup>	VOUCHER
124	<i>Pipturus albidus</i> (Hook. & Arnott) A. Gray	E	So. Kona, H	Morden 1105
476	<i>Pipturus ruber</i> A. Heller	E	Wahiawa Stream, K	Morden 1359
Verbenaceae				
917	<i>Vitex rotundifolia</i> L. fil.	I	Princeville, K	Morden 1420
Violaceae				
524	<i>Isodendrion hosakae</i> St. John	E	Pu'u Nohonaohae, H	Morden 1405
Viscaceae				
284	<i>Korthalsella complanata</i> (Tiegh.) Engl.	I	Waimea, H	Morden 1197
481	<i>Korthalsella complanata</i> (Tiegh.) Engl.	I	Wahiawa Stream, K	Morden 1364
162	<i>Korthalsella cylindrica</i> (Tiegh.) Engl.	E	So. Kona, H	Morden 1133
914	<i>Korthalsella cylindrica</i> (Tiegh.) Engl.	E	Alaka'i Swamp, K	Motley 1423
484	<i>Korthalsella cylindrica</i> (Tiegh.) Engl.	E	Wahiawa Stream, K	Morden 1367
913	<i>Korthalsella latissima</i> (Tiegh.) Danser	E	Alaka'i Swamp, K	Motley 1422
911	<i>Korthalsella platycaula</i> (Tiegh.) Engl.	I	Alaka'i Swamp, K	Motley 1420
480	<i>Korthalsella platycaula</i> (Tiegh.) Engl.	I	Wahiawa Stream, K	Morden 1363
912	<i>Korthalsella remyana</i> Tiegh.	E	Alaka'i Swamp, K	Motley 1421
Zygophyllaceae				
352	<i>Tribulus cistoides</i> L.	I	Kāne'ohe, O	Morden 1222

<sup>a</sup> E, endemic; I, indigenous; P, of possible Polynesian introduction.

<sup>b</sup> H, Hawai'i; K, Kaua'i; L, Lāna'i; M, Maui; Mo, Moloka'i; O, O'ahu.

<sup>c</sup> Greenhouse-grown material.

<sup>d</sup> Material obtained from botanical gardens or arboreta.

courage those interested in assisting us with this cause to collect plants during their own field studies and send them to us (preferably with some advance communication). At some future time this may be the only link to the genetic variation that once existed in the Hawaiian flora.

#### ACKNOWLEDGMENTS

We thank Winona Char for her continual support and help with the field collections, identifications, and our discussions on taxonomic "problem groups" in the flora; David Lorence (National Tropical Botanical Garden) for arranging travel to remote parts of Kaua'i and plant identifications; Cliff Smith (Cooperative Park Studies Unit) for travel expenses; Earl Pawn and Robert Hobdy (Hawai'i Division of Forestry and Wildlife), Randy Bartlett (Maui Land and Pineapple), Barrie Fox-Morgan, and Ed Misaki (The Nature Conservancy of Hawai'i) for help obtaining access to various properties; Dianella Howarth for collecting and isolating

DNA from many of the *Scaevola* species; Gerald Carr and Benton Pang (University of Hawai'i Department of Botany), Clyde Imada (Bishop Museum), Steve Perlman and Ken Wood (National Tropical Botanical Garden), Joel Lau (The Nature Conservancy of Hawai'i), Don Drake, John Obata, and Randy Walker for accompanying us on field collections; individuals listed in Table 1 for collecting plant materials for us; and Andy Taylor for his review of the manuscript.

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