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GRAY HERBARIUM

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Lobelia gloria-montis

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Vegetative Key to the Common Grasses of Hawai'i

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The grasses of Hawai'i are one of the more poorly understood and least studied components of our rich tropical flora. This is in large part due to a complex nomenclature unique to the family and there being few native species (relative to a large number of species) now found among the islands. Further, many collections of grasses are made during seasons when floral characters are not available for identification. It is not uncommon that floral characters are available for only a short length of the growing season for some species (*Sporobolus virginicus* and *Stenotaphrum secundatum*) or not at all (*Pennisetum clandestinum* in many pastures). All treatments pertaining to Hawaiian grasses emphasize the features of the inflorescence (paniculate or spicate) and the spikelet (glumes, lemmas, paleas, and awns). Thus, identifications for many collections will be difficult at best. Repeat visits to a site are not always possible given the Hawaiian terrain and remote study locations.

The intent of this work was to produce a treatment that will be of utility to researchers, land managers and others, with minimum of equipment (e. g., only a hand lens) necessary for identification, and many of the key character distinctions illustrated.

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"...advance the science of botany in all its applications, encourage research in botany in all its phases, promote the welfare of its members and develop the spirit of good fellowship and cooperation among them."

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There are many vegetative features of the grass plant that are very useful for diagnostic determinations between species, and at times the only means by which species may be distinguished. Additionally, this will be an invaluable resource for verification of species determinations if floral characters are also available. As should be expected in a large family such as the Poaceae, the evolution of vegetative characters is more closely tied to the ecology of the species rather than phylogenetic affinity. Species of the same genus will occasionally key together, but these are exceptions rather than the rule, and a key based on vegetative characters will not be very phylogenetically informative.

Although optimal, a treatment including all species known to occur in Hawai'i was not possible at this time because of funding limitations and a desire to provide a usable key in a timely manner. As such, we have focused efforts here on species that are commonly encountered in field studies and surveys. Many of the interesting endemic species in our flora were not included because of their rarity or occurrence in remote locations. However, this treatment was set up with the intention that future revisions would be made and published; a web version of the key with illustrations will be available in the coming year. As such, users are encouraged to make suggestions concerning additional species that should be added to future revisions.

HAWAIIAN GRASSES

By the most recent count, there are 147 species among 67 genera of grasses in Hawai'i, of which only 39 species are endemic and eight are indigenous (O'Connor 1990). Rotar (1968) reports the actual number to be over 500 species, but many of these are the consequence of local introductions for cattle forage or other agricultural uses and were not self-sustaining or persisting in the flora. However, the actual number of species now present in the islands is likely to be somewhere between these two estimates.

There have been several treatments of the Hawaiian grasses during the early part of this century focusing primarily upon the rangeland grasses (McClelland 1915; Hitchcock 1922, Ripperton et al, 1933; Whitney et al. 1939), and providing either keys, descriptions, line drawings, and/or distribution data. Consequently many of the native species were excluded from these treatments, and the focus was largely upon common plants or those species of economic importance.

Rotar (1968) provides the most comprehensive list of species reported from the islands, and provides keys to and descriptions of the genera. However, there are no

keys, descriptions, or distribution data for the species, and is thus of little value beyond a detailed checklist. Further, many of the species listed have not persisted in the flora. The treatments by O'Connor (1990) and Davidse (1990) for the *Manual of the flowering plants of Hawai'i* (Wagner et al. 1990) are the most complete treatment of the Hawaiian taxa available, providing keys, descriptions and distribution data for most of the species known. However, complaints have been raised by many researchers, land managers, and ecologists that these keys are difficult to use. As a consequence, many collections are incompletely identified (i.e., to genus only) or are misidentified. It was fortuitous that in 1995 Dr. Derek Clayton, Curator of Agristology at the Royal Botanical Gardens, Kew (England) was resident at the B. P. Bishop Museum and made determinations for numerous unidentified collections. Drawing upon his vast knowledge of world grasses, Dr. Clayton also made several nomenclature changes by associating the proper name with the species representatives that have been introduced to our flora (see Herbst & Clayton 1997). Although these are few, their usage here may be confusing to some familiar with the old names. As such, a checklist with cross-listed names in Wagner et al. (1990) is included.

GRASSES AND "GRASS-LIKES"

Vegetatively, grasses may be difficult to distinguish from sedges and rushes, the vegetation of these others often being described as "grass-like." Because of these similarities, it is best if flowering material is present to aid in this distinction. However, as stated previously this is not always possible. There are a few characteristics that help distinguish these groups, and these may be helpful. **Grasses** (Poaceae) can be annual or perennial and are found in a diversity of habitats from dry to moist regions. The plants may have rhizomes, stolons or grow in tufts and commonly have hollow culms although solid culms are characteristic of some groups. Culms are branched or unbranched, and are round or elliptic in cross-section. The leaf sheath is open and a ligule is usually present at the junction of the sheath and blade. **Sedges** (Cyperaceae) are grass-like perennials and are commonly found in damp, wet or marshy areas. The plants have creeping rhizomes with solid culms (stems) which are often, though not always, three-angled in cross-section. The culms are usually unbranched. The plant may be leafless, or if leaves are present they are usually in a tuft around the base of the culm. The leaf has a grass-like blade, there is no ligule at the junction of sheath and blade, and the sheath is usually closed around the culm. **Rushes** (Juncaceae) are less common

than sedges or grasses. They are found in wet areas (though some Hawaiian representatives are in dry habitats), have a rounded, wiry-looking culm with a solid,

large pith. The leaf blade is flat to rounded with an open leaf sheath.

VEGETATIVE KEY

Key A

- 1 Leaf blade with obvious midvein 2
 1 Leaf blade without obvious midvein (2 prominent lateral veins in *Aristida adscencionis*) 26
- 2 (1) Leaf blade scabrous or glabrous, pubescence on upper or lower blade completely absent 3
 2 Leaf blade pubescence on upper or lower surface, (at least some may have widely scattered hairs or hairs restricted to near the collar in some species) Key B
- 3 (2) Membranous ligule absent (less than 0.5mm) or ligule a row of hairs 4
 3 Membranous ligule present (greater than 0.5mm) 37
- 4 (3) Rhizomes or stolons absent 5
 4 Rhizomes or stolons present (not including decumbent culm rooting at lowermost nodes) 13
- 5 (4) Blade length greater than 30 cm; plants stout *Pennisetum purpureum*
 5 Blade length less than 30 cm (mostly so in *Echinochloa crus-galli*) 6
- 6 (5) Hairs at collar present 7
 6 Hairs at collar absent 12
- 7 (6) Culms generally unbranched *Isachne distichophylla*
 7 Culms branched, plants tufted (at least at base) 8
- 8 (7) Plants typically small, less than 20 cm tall (including inflorescence); weedy habitats *Eragrostis amabilis*
 8 Plants greater than 20 cm tall (including inflorescence); pastures and disturbed habitats 9
- 9 (8) Leaf sheath margins hyaline *Rytidosperma pilosum*
 9 Leaf sheath margins not hyaline 10
- 10 (9) Culm nodes pubescent *Melinis repens*
 10 Culm nodes glabrous 11
- 11 (10) Leaf blades 1-3 mm wide *Eragrostis pectinacea*
 11 Leaf blades 3-6 mm wide *Eragrostis cilianensis*
- 12 (6) Leaf blade margins white, tan, or brown and lightly scabrous; leaf blades usually greater than 5 mm broad 18
 12 Leaf blade margins green to edge, not scabrous; leaf blade 2-5 mm broad *Sacciolepis indica*
- 13 (4) Plants mat-forming, low growing 14
 13 Plants tufted, upright, not mat-forming 18
- 14 (13) Leaf sheaths along stolon closely overlapping; leaf blades erect, not spreading *Chrysopogon aciculatus*
 14 Leaf sheaths along stolon or rhizome loosely overlapping; leaf blades spreading or distichous 15
- 15 (14) Leaf tips subacute or rounded; leaf sheath strongly flattened or keeled 16
 15 Leaf tips attenuate; leaf sheath rounded or folded 17

16 (15) Common in wet pastures, disturbed wet forests and bogs	<i>Axonopus fissifolius</i>
16 Common lawn grass, naturalized on beaches, dunes, and along roadsides	<i>Stenotaphrum secundatum</i>
17 (15) Leaf collar with silky hairs	<i>Cynodon dactylon</i>
17 Leaf collar glabrous, silky hairs absent	<i>Chloris divaricata</i> var. <i>cynodontioides</i>
18 (13) Culm nodes pubescent	<i>Melinis repens</i>
18 Culm nodes glabrous	19
19 (18) Leaf collar with no hairs	20
19 Leaf collar with hairs present	22
20 (12,19) Leaf blade length less than 7 cm; blade width less than 2 mm <i>Chloris divaricata</i> var. <i>divaricata</i>
20 Leaf blade length greater than 7 cm; blade width greater than 2 mm	21
21 (20) Leaf blade length 7-15 cm	<i>Echinochloa colona</i>
21 Leaf blade length usually over 20 cm	<i>Echinochloa crus-galli</i>
22 (19) Sheath compressed or keeled at base of plant	<i>Chloris gayana</i>
22 Sheath not compressed or keeled at base of plant	23
23 (22) Plants has wiry stolens or upright stems, not tufted	<i>Paspalum conjugatum</i>
23 Plants tufted	24
24 (23) Plants with prominent hard, scaly rhizomes	<i>Eragrostis atropioides</i>
24 Plants with weak, non-scaly rhizomes	25
25 (24) Plants common on moist or wet slopes in ravines and mesic forests, usually in part shade, 170-2040 m	<i>Eragrostis grandis</i>
25 Plants common on sand dunes, grasslands, open sites in dry forest and exposed slopes and ridges or cliffs, 0-1130 m	<i>Eragrostis variabilis</i>
26 (1) Leaf blade less than 5 cm long	27
26 Leaf blade greater than 5 cm long	28
27 (26) Leaf blade greater than 1 mm wide; strongly rhizomatous perennial; commonly found in sand dunes and coastal areas	<i>Sporobolus virginicus</i>
27 Leaf blade less than 1 mm wide, finely bladed; occasionally escaped from cultivation	<i>Zoysia matrella</i> var. <i>pacifica</i>
28 (26) Plants weakly rooted; annuals	29
28 Plants strongly rooted; rhizomatous or cespitose perennials	31
29 (28) Ligule ciliate	<i>Aristida adsensionis</i>
29 Ligule membranous	30
30 (29) Hyaline margin of sheath 0.5-1 mm wide	<i>Vulpia myuros</i>
30 Hyaline margin of sheath less than 0.5 mm wide	<i>Vulpia bromoides</i>
31 (28) Leaf sheath or blade completely glabrous at collar; sheath hyaline	32
31 Leaf sheath or blade pubescent near collar, at least minutely; sheath not hyaline	33
32 (31) Ligules minute, 0.5 mm	<i>Festuca rubra</i>
32 Ligules large, greater than 5.0 mm	<i>Deschampsia nubigena</i>
33 (31) Ligule greater than 1 mm; leaf blade involute, convolute or folded	34
33 Ligule less than 0.5 mm; leaf blade flat (folded or involute when dry)	35

34 (33) Ligule a row of silky hairs; leaf blade margins scabrous	<i>Pennisetum setaceum</i>
34 Ligule membranous; leaf blade margins smooth	<i>Stipa cernua</i>
35 (33) Leaf blade 3-5 mm wide, usually greater than 20 cm long	<i>Sporobolus africanus</i>
35 Leaf blades less than 3 mm wide, usually less than 10 cm long	36
36 (35) Leaf blade and sheath margin with silky pilose hairs near collar	<i>Eragrostis monticola</i>
36 Leaf sheath margin with sparsely pilose hairs near collar, hairs not extending along blade margin	<i>Sporobolus diander</i> or <i>S. indicus</i>
<i>(very difficult to distinguish the Sporobolus species vegetatively)</i>	
37 (3) Plants with upright culms greater than 2 m in height; culm internode greater than 4 mm in diameter	36
37 Plants with upright culms less than 2 m in height; culm internode less than 4 mm in diameter	Key C
38 (37) Leaf blades constricted near base to a short "petiole"; culms "woody"	39
38 Leaf blades not constricted to a "petiole"; culms herbaceous	40
39 (38) Leaf blades less than 15 cm in length	<i>Phyllostachys nigra</i>
39 Leaf blades generally greater than 20 cm in length	<i>Schizostachyum glaucifolium</i>
40 (38) Culm internodes hollow	<i>Arundo donax</i>
40 Culm internodes solid	41
41 (40) Leaf blade usually 3 cm wide, or wider; leaf blade is less than 50 cm long	<i>Coix lachryma-jobi</i>
41 Leaf blade usually less than 2 cm wide; if blade is greater than 2 cm wide, then leaf length is greater than 50 cm long	42
42 (41) Leaf sheath with long silky hairs, at least toward collar or on margins	43
42 Leaf sheath glabrous	45
43 (42) Culm nodes with scattered hairs	44
43 Culm nodes glabrous	<i>Hyparrhenia rufa</i>
44 (43) Membranous ligule 3-5 mm long	<i>Paspalum urvillei</i>
44 Membranous ligule 1-2.5 mm long	<i>Panicum maximum</i>
45 (42) Plants perennials; no rhizomes present; naturalized in dry pastures, roadsides and other dis- turbed areas	<i>Themeda villosa</i>
45 Plants with rhizomes or a rhizomatous perennial; naturalized in mesic to wet disturbed sites	46
46 (45) Culms 20-40 dm tall or more; membranous ligule 3-4 mm long	<i>Saccharum spontaneum</i>
46 Culms 5-15 dm tall; membranous ligule 1.5-3.0 mm long; culm nodes with short fine hairs, hairs sometimes also present at collar	<i>Sorghum halpense</i>

KEY B*Pubescent leaves without obvious midveins*

1 Leaf blades flat and broad in middle, narrowing to a cuneate or attenuate base	2
1 Leaf blades flat, folded or variously involute, but not narrowing noticeably at the base	4
2 (1) Leaf blades greater than 20 cm long, usually greater than 3 cm wide (at least some blades)	<i>Setaria palmifolia</i>
2 Leaf blades less than 15 cm long, less than 2.5 cm wide	3
3 (2) Leaf sheath margins prominently ciliate; bristle-like hairs at leaf collar 1-2 mm long; membra- nous ligule 0.5-0.8 mm in length	<i>Oplismenus hirtellus</i>
3 Leaf sheath margins ciliate or membranous; bristle-like hairs at collar to 1 mm long; membranous ligule approximately 1 mm in length	<i>Oplismenus compositus</i>

(very difficult to distinguish species in this couplet vegetatively)

4 (1) Culm internodes solid	5
4 Culm internodes hollow	15
5 (4) Hairs present along margin of leaf blade near collar	6
5 Hairs present or absent along margin of leaf blade at collar, but if present then not along margins of blade near collar	12
6 (5) Leaf sheath margins ciliate or variously pubescent	7
6 Leaf sheath margins glabrous or with hairs restricted to collar area	10
7 (6) Leaf gradually tapering to an acuminate tip; leaf blade margins white or light green	8
7 Leaf quickly terminating to a subacute or rounded tip; leaf blade margins green	<i>Axonopus fisifolius</i>
8 (7) Ligule membranous	<i>Paspalum fimbriatum</i>
8 Ligule ciliate	9
9 (8) Leaf sheath margin densely ciliate from node to collar along one margin and glabrous or hyaline along other margin	<i>Brachiaria subquadripara</i>
9 Leaf sheath margin not densely ciliate, pubescence along both margins but mostly near collar	<i>Cenchrus ciliaris</i>
10 (6) Leaf blade quickly terminating to a subacute rounded tip; leaf sheath strongly flattened or keeled	<i>Axonopus fissifolius</i>
10 Leaf blade gradually tapering to an attenuate tip; leaf sheath rounded or folded	11
11 (10) Culm nodes pubescent	<i>Bothriochloa pertusa</i>
11 Culm nodes glabrous	<i>Dactyloctenium aegyptium</i>
12 (5) Leaf blade pubescent near collar on adaxial surface, hairs arising along row medial to margin	<i>Chloris barbata</i>
12 Leaf blade pubescent on adaxial and or abaxial surface, hairs scattered over entire length of blade	13
13 (12) Plants annual; leaf blades flat	<i>Digitaria ciliaris</i>
13 Plants perennial; blades often folding along midvein	14
14 (13) Plants mat-forming, low growing	<i>Chloris divaricata</i> var. <i>cynodontioides</i>
14 Plants clumping, upright, not mat-forming	<i>Chloris divaricata</i> var. <i>divaricata</i>
15 (4) Leaf sheaths strongly keeled	16
15 Leaf sheaths rounded or weakly folded, but not keeled	19
16 (15) Leaf sheath densely pubescent over entire surface	<i>Cenchrus echinatus</i>
16 Leaf sheath glabrous or sparsely pubescent	17
17 (16) Leaf blades strongly keeled or folded, densely pubescent on adaxial surface (especially near collar)	<i>Andropogon virginicus</i>
17 Leaf blades flat or folded, glabrous or sparsely pubescent on adaxial or abaxial surface	18
18 (17) Plants annual or perennial; abaxial leaf blade generally smooth; leaf blade length 10-30 cm; collar glabrous to densely pubescent	<i>Chloris virgata</i>
18 Plants tufted perennials; abaxial leaf blade generally scabrous; leaf blade length 5-15 cm; collar glabrous	<i>Chloris radiata</i>
19 (15) Ligule completely membranous, occasionally with erose or lacerate apex	20
19 Ligule a ring of hairs or ligule a ciliate membrane	27

20 (19) Plants tufted annuals with poorly developed root system	21
20 Plants tufted or rhizomatous perennials with well developed root system.....	23
21 (20) Leaf sheath pubescent near collar, becoming glabrous toward node	<i>Bromus rigidus</i>
21 Leaf sheath pubescent over entire surface	22
22 (21) Ligule greater than 2 mm	<i>Digitaria setigera</i>
22 Ligule less than 2 mm	<i>Bromus hordeaceus</i>
23 (20) Culm nodes pubescent	24
23 Culm nodes glabrous	26
24 (23) Culm internode pubescent just below node	<i>Holcus lanatus</i>
24 Culm internode glabrous just below node	25
25 (24) Leaf sheath pubescent above node	<i>Brachiaria mutica</i>
25 Leaf sheath glabrous above node	<i>Dicanthium sericeum</i>
26 (23) Ligule less than 1 mm	<i>Ehrharta stipoides</i>
26 Ligule greater than 3 mm	<i>Trisetum glomeratum</i>
27 (19) Culm nodes glabrous	28
27 Culm nodes pubescent	34
28 (27) Collar glabrous	<i>Setaria verticillata</i>
28 Collar pubescent	29
29 (28) Leaf sheath and collar (including blade near collar) glabrous or with hairs less than 1 mm long	30
29 Leaf sheath glabrous or with short pubescence, collar and or blade near collar with hairs greater than 2 mm long	31
30 (29) Ligule a ring of hairs 1-2 mm in length	<i>Pennisetum clandestinum</i>
30 Ligule membranous with ciliate fringe, usually less than 1 mm in length	<i>Panicum repens</i>
31 (29) Leaf blades flat, usually greater than 4 mm wide	32
31 Leaf blades usually involute (at least some), less than 3 mm wide	33
32 (31) Leaf blades densely pubescent on abaxial and adaxial surfaces	<i>Pennisetum polystachion</i>
32 Leaf blades with few scattered hairs on abaxial or adaxial surfaces	<i>Setaria parviflora</i>
33 (31) Long hairs at collar do not extend onto leaf blade; leaf blades 3-12 cm long	<i>Rhizosperma pilosa</i>
33 Long hairs at collar extending onto leaf blade; leaf blades 10-25 cm long	<i>Eragrostis leptophylla</i>
34 (27) Dense or velvety pubescence present on leaf blade, sheath, node, and internodes	35
34 Pubescence present but not on all structures as above	36
35 (34) Plants caespitose annuals; foliage not viscid	<i>Panicum torridum</i>
35 Plants creeping, trailing perennials; foliage often viscid	<i>Melinis minutiflora</i>
36 (34) Ligule ciliate; leaf blades usually less than 20 cm in length	<i>Melinis repens</i>
36 Ligule membranous with ciliate fringe; leaf blades usually greater than 30 cm in length	37
37 (36) Leaf sheath and blade mostly glabrous with short appressed hairs near collar; plants usually rhizomatous	<i>Sorghum halpense</i>
37 Leaf sheath (and blade near collar) with hairs greater than 1 mm long; plants tufted	<i>Panicum maximum</i>

Key C

*Plants with obvious midveins, blade scabrous or glabrous, membranous
ligule, upright culms less than 2 m and internodes less than 4 mm*

- 1 Culm nodes pubescent (may be visible only with hand lens) 2
 1 Culm nodes glabrous 8
- 2 (1) Plants with weak, sprawling culms or mat forming plants 3
 2 Plants clumping or tufted erect plants, not mat forming 4
- 3 (2) Leaf blade linear, 4-8 mm wide; found in pastures and along roadsides *Brachiaria subquadripata*
 3 Leaf blade lanceolate to ovate, 8-25 mm wide; common in shaded sites in
 mesic valleys and forests *Oplismenus compositus*
- 4 (2) Culm nodes with dense, long hairs greater than 1.0 mm long 5
 4 Culm nodes with short hairs less than 0.25 mm long 7
- 5 (4) Leaf sheath glabrous; short appressed hairs at collar less than 0.5 mm long *Bothriochloa barbinodis*
 5 Leaf sheath usually pubescent (at least near collar); hairs at collar greater than 1.0 mm long 6
- 6 (5) Leaf blade 2-6 mm wide *Dichanthium sericeum*
 6 Leaf blade 6-30 mm wide *Panicum maximum*
- 7 (4) Leaf blade usually folded or involute, 1-2 mm wide; culms 2.5-6.5 dm tall *Koeleria nitida*
 7 Leaf blade flat, 4-15 mm wide; culms 5-15 dm tall *Sorghum halpense*
- 8 (1) Leaf tip curved, boat-shaped 9
 8 Leaf tip narrowly attenuate 10
- 9 (8) Culms 0.3-2 dm tall; annuals; occurring in disturbed mesic habitats, including roadsides, pas-
 tures, urban sites, and disturbed mesic and wet forests, 0-1830 m *Poa annua*
 9 Culms 3-6.5 dm tall; perennials; naturalized in disturbed mesic to subalpine forests and alpine sites,
 1220-4025 m *Poa pratensis*
- 10 (8) Basal leaf sheaths compressed-keeled *Heteropogon contortus*
 10 Basal leaf sheaths rounded or compressed but not distinctly keeled 11
- 11 (10) Leaf blade length less than 15 cm 12
 11 Leaf blade length greater than 15cm 26
- 12 (11) Leaf blade width (largest blades) 6 mm or less 13
 12 Leaf blade width (largest blades) greater than 6 mm 25
- 13 (12) Ligule less than 2 mm in length 14
 13 Ligule greater than 2 mm in length 22
- 14 (13) Plants are tufted or weakly rhizomatous annuals or perennials 15
 14 Plants are strongly rhizomatous perennials *Paspalum vaginatum*
- 15 (14) Culm internodes solid *Digitaria violescens*
 15 Culm internodes hollow 16
- 16 (15) Weakly rhizomatous perennial; culms usually decumbent; found in moist shaded
 understory *Ehrharta stipoides*
 16 Tufted perennials; culms usually upright, occasionally decumbent at base 17
- 17 (16) Auricles present 18
 17 Auricles absent 20

18 (17) Membranous sheath margins extend into membranous auricles at leaf collar	<i>Leptochloa uninervia</i>
18 Sheath margins not membranous; broad auricle lobes at leaf collar (<i>Lolium</i>)	19
19 (18) Leaf blades mostly flat	<i>Lolium perenne</i>
19 Leaf blades flat, becoming involute along leaf margins near tip	<i>Lolium multiflorum</i>
(very difficult to distinguish species in this couplet vegetatively)	
20 (17) Ligule 1.5-2.0 mm	<i>Leptochloa uninervia</i>
20 Ligule 0.5-1.0 mm	21
21 (20) Plants annual or perennial; abaxial leaf blade generally smooth; leaf blade length 10-30 cm; collar glabrous to densely pubescent	<i>Chloris virgata</i>
21 Plants tufted perennials; abaxial leaf blade generally scabrous; leaf blade length 5-15 cm; collar glabrous	<i>Chloris radiata</i>
22 (13) Lower culm nodes usually erect, not distinctly geniculate	23
22 Lower culm nodes distinctly geniculate	24
23 (22) Leaf blade width usually less than 2 mm	<i>Agrostis avenacea</i>
23 Leaf blade width usually 4-6 mm	<i>Ehrharta calycina</i>
24 (22) Leaf blade finely scabrous along margins	<i>Polypogon monspeliensis</i>
24 Leaf blade not scabrous along margins	<i>Polypogon viridis</i>
(very difficult to distinguish species in this couplet vegetatively)	
25 (12) Plants weakly perennial, culms trailing; ligule membranous with ciliate fringe; leaf blade distinctly narrowing at base	<i>Oplismenus compositus</i>
25 Plants tufted, annual or weak perennial; ligule ring of hairs; leaf blade not distinctly narrowing at base	<i>Setaria verticillata</i>
26 (11) Ligule greater than 3 mm	27
26 Ligule less than 3 mm	30
27 (26) Leaf blade margins white or light green, distinctly different from remainder of leaf	28
27 Leaf blade margins same color as remainder of leaf blade	29
28 (27) Leaf blade scabrous along margin and or along veins	<i>Dactylis glomerata</i>
28 Leaf blade not scabrous along margin or veins	<i>Digitaria insularis</i>
29 (27) Leaf collar with hairs up to 5 mm long	<i>Paspalum dilatatum</i>
29 Leaf collar glabrous	<i>Agrostis stolonifera</i>
30 (26) Culm internodes solid	31
30 Culm internodes hollow	33
31 (30) Culm internodes flattened or compressed	<i>Eleusine indica</i>
31 Culm internodes rounded	32
32 (31) Leaf blades approximately 1.5 mm wide	<i>Cymbopogon refractus</i>
32 Leaf blades 5-8 mm wide	<i>Hyparrhenia rufa</i>
33 (30) Leaf blade greater than 7 mm wide	<i>Paspalum scrobiculatum</i>
33 Leaf blade less than 6 mm wide	34
34 (33) Auricle lobes at leaf collar present	35
34 Auricle lobes at leaf collar absent	36

35 (34) Membranous sheath margins extending into membranous auricles at leaf collar	<i>Leptochloa uninervia</i>
35 Sheath margins not membranous, broad auricle lobes at leaf collar	<i>Lolium perenne</i>
36 (34) Ligule less than 1 mm	<i>Chloris virgata</i>
36 Ligule greater than 1 mm	37
37 (36) Leaf blade width less than 3 mm	<i>Leptochloa uninervia</i>
37 Leaf blade width greater than 4 mm	<i>Agrostis stolonifera</i>

GLOSSARY

abaxial The side facing away from the axis, such as the underside of a leaf. Compare adaxial.

acuminate Gradually tapering to a sharp point and forming concave sides along the tip.

acute Tapering to a pointed apex with more or less straight sides; pointed tip or base with straight or somewhat curve outward margins, forming an angle between 45° and 90° at the tip or base.

adaxial The side toward the axis, such as the surface of a leaf that faces the stem during development, i.e., the upper surface. Compare abaxial.

annual A plant which germinates from seed, flowers, sets seed, and dies in the same year or growing season.

appressed Pressed close or flat against another organ, as in hairs.

attenuate Tapering very gradually to a long, slender tip or base, more extreme than acute or acuminate.

blade The flat expanded portion of a leaf or other structure.

cespitose Growing in dense tufts.

ciliate Fringed with hairs.

collar The area on the outside of a grass leaf at the juncture of the sheath and blade.

convolute When the margins of the blades mutually envelop each other. Used in reference to curled leaf blades when one margin overlaps the other.

culm A hollow or pithy stalk or stem of a grass.

cuneate Wedge-shaped, with the narrow part at the point of attachment.

decumbent A growth habit in which a portion of the stem lies close to the ground, with the terminal portion of the stem erect or ascending.

epidermis The outermost cellular layer.

erose With margin irregularly toothed, as if gnawed.

geniculate. With abrupt knee-like bends in a structure, as in the bend of a culm at the node.

glabrous Smooth; hairless.

herbaceous With the characteristics of an herb; not woody.

hyaline Thin, membranous, and translucent or transparent.

inflorescence The flowering portion of a plant.

internode The part of a stem between consecutive nodes, often obscured by leaf sheath.

involute Blade margins completely inrolled toward the upper side.

keel A sharp or conspicuous longitudinal ridge, like the keel of a boat.

lacerate Torn, or with an irregular, jagged margin; cut, or cleft irregularly, as if torn.

lanceolate Lance-shaped; much longer than wide, widest below the middle and tapering to the apex.

leaf Composed of two portions in grasses, the sheath and blade, the junction of which is referred to as the collar.

ligule The appendage projecting from the inner side of the junction of the leaf sheath and blade; may be membranous, ciliate, or membranous appendage terminating with hairs (a ciliate membrane).

margin The edge, as in the lateral edge of a leaf blade.

medial Of the middle; situated in the middle.

membranous Thin, soft, flexible, and more or less translucent like a membrane.

node The position on the stem where leaves or branches originate.

ovate Egg-shaped, with the axis widest below the middle.

perennial A plant living more than one or year or growing season; commonly referring to herbaceous plants whose above-ground parts die back annually.

petiole Usually referring to a leaf stalk that attaches the blade to the stem; here in reference to a constriction of the proximal end of the leaf blade near the collar, as in bamboos.

pubescent Pubescent with long, basically straight, rather soft, spreading to erect hairs.

pubescent Bearing hairs of any kind.

rhizome A horizontally growing underground stem, rooting at nodes, giving rise to new plants; associated leaves often absent or reduced to bladeless sheaths.

rounded A term applied to a smoothly curving apex of a structure or organ, the curvature of which, if continued, would roughly form a semicircle.

scabrous Having short stiff epidermal hairs that are wide at the base narrowing to a point (usually directed

toward the leaf apex), giving a rough-to-the-touch surface when running your finger from the leaf apex toward the base.

sheath The lower portion of the grass leaf from the node to the collar, forming a tubular structure that partly or completely surrounds the culm.

stolon An elongate, horizontal, above-ground stem usually rooting at the nodes, giving rise to a new plant.

subacute Slightly acute.

tufted Arranged in a dense cluster.

viscid Sticky or gummy.

CHECKLIST AND SYNONYMY

The following is a list of species present in this key followed in some cases by a common synonym (in brackets) that has been applied to them in the past. The grass collections at Bishop Museum (BISH) have recently been thoroughly reviewed by Derek Clayton (Curator of Grasses, Kew Gardens and authority on grasses of the world) and the nomenclature used in this key is consistent with the identification of grasses in this collection (Herbst & Clayton 1997). Two species that have been found frequently in disturbed habitats in recent time and are included here (*Aristida adscensionis* and *Brachiaria subquadripara*) were mentioned in Wagner et al. (1990), but the extent of their distribution was unknown at that time and full descriptions of them are not available there. *Ehrharta calycina* was not mentioned by Wagner et al. (1990), but is now prevalent in some regions of the Big Island. *Zoysia matrella*, a horticultural species that is occasionally escaping in to natural habitats, is also listed.

Agrostis avenacea J. G. Gmelin

Agrostis stolonifera L.

Andropogon virginicus L.

Aristida adscensionis L.

Arundo donax L.

Axonopus fissifolius (Raddi) Kuhl.

Bothriochloa barbinodis (Lag.) Herter

Bothriochloa pertusa (L.) A. Camus

Brachiaria mutica (Forssk.) Stapf

Brachiaria subquadripara (Trin.) Hitchc.

Bromus hordeaceus L.

[*Bromus mollis* L.]

Bromus rigidus Roth

Cenchrus ciliaris L.

Cenchrus echinatus L.

Chloris barbata (L.) Sw.

Chloris divaricata R. Br.

var. *cynodontioides* (Balansa) Lazarides

var. *divaricata*

Chloris gayana Kunth

Chloris radiata (L.) Sw.

Chloris virgata Sw.

Chrysopogon aciculatus (Retz.) Trin.

Coix lachryma-jobi L.

Cymbopogon refractus (R. Br.) A. Camus

Cynodon dactylon (L.) Pers.

Dactyloctenium aegyptium (L.) Willd.

Deschampsia nubigena Hillebr.

Dichanthium sericeum (R. Br.) A. Camus

Digitaria ciliaris (Retz.) Koeler

Digitariainsularis (L.) Mez ex Ekman

Digitaria setigera Roth

Digitaria violescens Link

Echinochloa colona (L.) Link

Echinochloa crus-galli (L.) P. Beauv.

Ehrharta calycina J. E. Smith

Ehrharta stipoides Labill.

Eleusine indica (L.) Gaertn.

Eragrostis amabilis (L.) Wight & Arnott

[*Eragrostis tenella* (L.) P. Beauv. ex
Roem. & Schult.]

Eragrostis atropioides Hillebr.

Eragrostis cilianensis (All.) Link

Eragrostis grandis Hillebr.

Eragrostis leptophylla Hitchc.

Eragrostis monticola (Gaud.) Hillebr.

Eragrostis pectinacea (Michx.) Nees

Eragrostis variabilis (Gaud.) Steud.

Festuca rubra L.

Heteropogon contortus (L.) P. Beauv.

ex Roem. & Schult.

Holcus lanatus L.

Hyparrhenia rufa (Nees) Stapf

Isachne distichophylla Munro ex Hillebr.

Koeleria nitida Nutt.

Leptochloa uniuervia (K. Presl) Hitchc. & Chase

Lolium multiflorum Lam.

Lolium perenne L.

Melinis minutiflora P. Beauv.

Melinis repens (Willd.) Zizka

[*Rhynchelytrum repens* (Willd.) Hubb.]

Oplismenus compositum (L.) P. Beauv.

Oplismenus hirtellus (L.) P. Beauv.

Panicum maximum Jacq.

Panicum repens L.

Panicum torridum Gaud.

Paspalum conjugatum Bergius

Paspalum dilatatum Poir.

Paspalum fimbriatum Kunth

Paspalum scrobiculatum L.

Paspalum urvillei Steud.

Pennisetum clandestinum Chiov.
Pennisetum polystachion (L.) Schult.
Pennisetum purpureum Schumach.
Pennisetumsetaceum (Forssk.) Chiov.
Phyllostachys nigra (Lodd.) Munro
Poa annua L.
Poa pratensis L.
Polypogon monspeliensis (L.) Desf.
Rytidosperma pilosum (R. Br.) Connor & Edgar
 [*Danthonia pilosa* R. Br.]
Saccharum spontaneum L.
Sacciolepis indica (L.) Chase
Schizostachyum glaucifolium (Rupr.) Munro
Setaria palmifolia (J. König) Stapf
Setaria parviflora (Poir.) Kerguelen
 [*Setaria gracilis* Kunth]
Setaria verticillata (L.) P. Beauv.
Sorghum halepense L.
Sporobolus africanus (Poir.) Robyns & Tournay
Sporobolus diander (Retz.) P. Beauv.
Sporobolus indicus (L.) R. Br.
Sporobolus virginicus (L.) Kunth
Stenotaphrum secundatum (Walter) Kuntze
Stipa cernua Stebb. & A. Löve
Themeda villosa (Poir.) A. Camus
Trisetum glomeratum (Kunth) Trin.
Vulpia bromoides (L.) S. F. Gray
Vulpia myuros (L.) C. C. Gmelin
Zoysia matrella (L.) Merr. var. *pacifica*

ACKNOWLEDGMENTS

We wish to thank USGS-BRD for financial support for this project, and Cliff Smith (Cooperative Parks Studies Unit) for seeing the need for this work and sharing our strong desire to make this treatment available. We also wish to thank Winona Char for help in determining the species list and our insightful discussions

about grasses. Thanks also to the many people that have reviewed earlier drafts of the key and their helpful suggestions. Appreciation is extended to the staff of the B. P. Bishop Museum (BISH) for helping with various aspects while studying their collections and organizing the specimen loan.

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Phytotherapeutic Properties of *Nelumbo nucifera* Across Asia and Hawai'i

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ABSTRACT. Ethnobotanical study of the lotus (*Nelumbo nucifera*) was conducted across Asia (India, China, Taiwan, Indonesia, Nepal, Thailand, Vietnam) and Hawai'i during the summers of 1994 to 1999. Information was gathered through interviews with native people, herbalists, and commercial growers. Highly regarded as a sacred plant by Hindus and Buddhists, the lotus symbolizes life, purity, peace, and harmony. The entire plant has proved to be useful to mankind. Religious, cultural, nutritional, and medicinal aspects of the lotus are discussed.

The lotus (*Nilumbo nucifera*) is native to India, China, Japan, Thailand, Vietnam, the Philippines, north Australia, and the Volga River Delta at the Caspian Sea (Slocum and Robinson, 1966). According to Hindu epics, the plant is known as the Sacred Lotus of India. From its blossom, growing from the navel of the God Narayana, sprang Brahma – the Absolute and Creator of the universe. Buddhists of India, Tibet, Nepal, China, and Japan hold the lotus in veneration. Like the Buddha, sitting in serene detachment in a sea of suffering, the lotus sits above the mud from which it springs, pure, and undefiled.

Lotus flowers are depicted in many Hindu and Buddhist art works. Buddha sitting on a lotus throne or standing on a lotus pedestal has been a recurring theme since the second century A.D. (Coomaraswamy, 1935).

The Sacred Lotus of India spread to Egypt, probably carried by ancient Roman spice traders around 500 B.C. (Slocum and Robinson, 1996). The plant was widely represented in Egyptian tomb wall paintings and sculptures. Dried lotus blossoms were found in sarcophagi. They were also used as decorative elements on pillars and columns in Egyptian architecture. The ancient Greek aniconic capital was meant to depict the lotus's twisted sepals (Slocum and Robinson, 1996).

Aside from its religious associations, the lotus also symbolizes life, for all parts of the plant are edible and medicinal. In China, the lotus was esteemed for its medicinal properties since 2700 B.C. (Slocum and Robinson, 1996).

Information concerning religious, cultural, nutritional, and medicinal aspects of the lotus was collected during summer field trips to China in 1994, India in 1996, Taiwan and Indonesia in 1997, Nepal and Thailand in 1998, Vietnam and Hawai'i in 1999.

BOTANICAL DESCRIPTIONS AND CULTIVATION

Nelumbo nucifera Gaertner (Nymphaeaceae), known as the Sacred Lotus, is native to India. A perennial aquatic plant, it has a 6-foot long petiole rising above the water, supporting an orbicular leaf of 20 – 36 inches in diameter. The tubular fleshy rhizome is 2 – 3 feet long with multiple joints. A cross section of the rhizome shows a number of cavities, concentrically arranged and terminating at the joints. Flowers are pink or white with 24 petals, emerging above water on a 6-foot long peduncle. Stamens are numerous and are shed early. About 25 pistils are embedded separately in a swollen inverted conc-shaped receptacle. The ¼ inch oblong fruit protrudes from each cavity.

There are two known varieties. The *N. nucifera* var. *rosea* is called Rose lotus, and is native to China and Japan. Flowers are rosy-pink with a yellow diameter supported by a 4 – 5 foot long petiole. Three hundred types of lotuses are grown in China, of which 125 cultivars and hybrids are cultivated at the Nanjing Botanical Gardens (Slocum and Robinson, 1996).

Nelumbo nucifera var. *caspicum* (the Russian lotus) is native to the Volga River Delta at the Caspian Sea. Flowers are red, 10 – 12 inches in diameter, and slightly fragrant. The leaf is 20 – 24 inches in diameter, remaining above water on a 5-foot petiole (Slocum and Robinson, 1996).

The lotus is a day bloomer. The flowers open in the morning, closing by mid-afternoon, to reopen and close the following day for three successive days. In Asia, the plants are cultivated in ponds next to Hindu and Buddhist temples. They are also grown in ponds at many tropical botanical gardens, are used for landscaping, and are propagated commercially for food and for medicine.

Lotuses can be planted in wooden barrels lined with black plastic, or in plastic water garden containers. A 2 – foot deep mixture of loamy top soil and composted manure is placed in the container and covered with 3 – 6 inches of water. Mature seeds or the jointed portions of the rhizome containing some roots and little shoots are used as planting materials. They have to be buried in the mud. As many as four fertilizer tablets (20 – 10 – 5) are delivered per month.

In Hawai'i, planting and harvesting are done simultaneously from July to March. When rhizomes are planted in April, the first young leaves appear in June, blossoming by July or August. The rhizome will mature in 7 months after planting.

RELIGION AND CULTURE

The lotus has tremendous religious and cultural significance in India and China. In the Vedas, the ancient holy texts of India, the lotus was first a companion of Vishnu. Lakshmi, the consort of Vishnu, the goddess of beauty, lived in a pink lotus house. The lotus is used as a metaphor for purity. The fragrant flowers and leaves arise untainted by the malodorous muddy water above which they sit. The lotus is also an emblem of peace and harmony in Buddhism, as the plant denotes ontologically a firm establishment amongst the possibilities or existence, denoting a detachment, a birth and manifestation of a truly wise man, the Buddha (Coomaraswamy, 1935).

In Indian art, its full-rounded shaped flower is equated with feminine curves – a symbol of the purest beauty. The goddess of fertility and procreation, Parvati, is depicted holding a lotus blossom. At weddings, the Chinese serve lotus seeds in tea as a wish for having many children. The sticky rhizome is used to symbolize the hope that nothing will separate the newlyweds (Clarke, 1997). Because of its soft petals and fragrant flower, the lotus is also associated with feminine beauty (Slocum and Robinson, 1996).

NUTRITION

Every part of the lotus plant is edible. The rhizome is rich in starch. The Chinese use it in soups, stirfries, rich cakes, and rich porridge (Wijayakusuma, 1992). The dried rhizome is made into sweets, ground into flour, used as a thickener in cooking, and as a coating for deep frying foods (Clarke, 1997). In Japan and Hawai'i, the lotus is made into fritters, pickles, and stews. In Vietnam, the whitish sweet crunchy rhizome is cut lengthwise into small thin pieces, and served in salad.

The young leaves, petioles, and receptacles, rich in

vitamin C, are eaten as potherbs in Indonesia. The dried leaves are used by the Chinese and Japanese as food wrappers, encasing sticky rice. The petals are served in salad in Thailand. Stamens and pollinia add a delightful aroma to tea in China and Vietnam. The highly nutritious fruits can be eaten raw or cooked and ground into flour to make a sweet paste filler for Chinese moon cakes. According to Pliny (A.D. 23 – 79), Egyptian bakers kneaded the fruits with milk or water to make bread (Slocum and Robinson, 1996).

MEDICINE

The use of medicinal culinary herbs to improve health and cure illness was already known during the Hsia dynasty (200 B.C.) in China. All parts of the lotus plant are prepared in many delicious Chinese meals to cure certain diseases. For example, incorporating lotus flowers, fruits, and rhizomes into rice porridge is believed to improve one's complexion and slow down the aging process. Soup containing lotus fruits and rhizomes is thought to improve blood circulation, general debility, to cure indigestion, and to lower blood pressure. The soup on the rhizome alone is good for joints, arthritis, and anemia (Wijayakusuma, 1992). Pudding made of rhizome flour is very nutritious, serves as a tonic, increases mental faculties, and is used to treat diarrhea and hemorrhages (Stuart, 1985).

A decoction of rhizomes is used as a hemostatic in hemoptysis, post-partum hemorrhage, hematuria and for bloody stools. The leaves and petioles are used as an antifebrile, antihemorrhagic, constructive to the blood and to induce labor. It is antidotal to poisonous fungi, and eruptive fevers, and cures skin diseases (Stuart, 1985). The flower is used as a cosmetic application to the face to improve the complexion, for heart problems, and to heal scratches (Anonymous, 1987). The stamen cures lung, liver, and heart infections (Dash, 1994). It is also reputed to increase virility, blacken the hair, and make joyful the countenance (Stuart, 1985). The receptacle is rich in carbohydrates, sugar, protein, fatty oil, phosphorus, and iron (Bui, 1998). It is used as antihemorrhagic, and to counteract the poisons of deleterious fungi. In combination with the fruits, this mixture is used as remedy against painful micturition. An application of fruits alone acts as a tonic, sedative, antidiarrheal, and is prescribed for depression, anxiety, insomnia, spermatorrhea, neurasthenia, and chronic enteritis (Nguyen, 1993; Keys, 1995). It is also used for treatments of skin diseases (Subramanyan, 1962).

Chemical analysis of the rhizome reveals the content of the alkaloids acginine, asparagin, and trinogelin. The leaves contain anonain, prociciferin, roemerin, and tannin, while pollen has nelumbin (Bui, 1998). The petiole is rich with nuciferine, O-nonuciferin, and roemerine. The receptacle is full with N-norarmepavine, N-nornuciferine, nuciferine, and oxoshinsunine. The embryo contains isoliensinine, lotusine, methylcorypalline, and neferine (Nguyen, 1993).

DISCUSSION

The relationship between proper dietary intake and good health is well understood. The entire lotus plant is edible, highly nutritious, and delicious as well. Utilizing them in medicinal culinary herbs, it is widely believed, will strengthen the immune system, and serve as a tonic for treating many ailments. Each part of the lotus plant contains some medicinal alkaloids. Pharmacological analysis offers some support for traditional claims regarding its therapeutic properties. Neferine, for example, an alkaloid obtained from the embryo, displays an ability to delay arrhythmia (Craker and Simon, 1987). Methylcorypalline contained in the embryo induces coronary dilation. Nuciferine, extracted from leaves and petioles, shows potential as an anticonvulsant (Nguyen, 1993).

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TREASURER'S REPORT JANUARY TO DECEMBER 1999

This 75th year of the Hawaiian Botanical Society was honored by May's memorable "grande fête anniversaire". A sumptuous Chinese banquet, sublime program, and warm fellowship combined to create an unforgettable evening. Mahalo once again to each of you, who donated time and effort to make our 75th commemorative celebration into a cherished lifetime souvenir.

In other business, while the Society remains sound financially, the Annual Fund spent about \$1200 more than it made this year. Although this red ink is partially from increased discretionary spending, shipping three instead of two Newsletters raised core expenses, copying and postage, by about 1/3. As shown below, copying and postage fees exceed income from annual dues, prompting the yearly reminder that dues adjustments may be needed once the Newsletter gathers steam.

Finally, the treasurer would like to thank K. Bartlett Durand, Jr. for his thorough financial audit of the Society's books for 1998.

1999 Annual Fund Summary:

<u>Income</u>		<u>Outgo</u>	
Annual Dues	\$1160.00	Copying	\$1149.15
75 th Anniversary	\$810.00	75 th Anniversary	\$1050.00
Lawsuit Return	\$250.00	Postage	\$666.04
Donations	\$195.00	Conserv. Council	\$300.00
Plantfest	\$60.00	½ Annual Payment	\$250.00
Interest	\$54.70	Science Fair	\$190.05
Bank Fee Return	\$10.00	Stationery	\$56.39
Newsletter Copies	<u>\$10.00</u>	Miscellaneous	\$25.00
	\$2549.70	Refreshments	<u>\$24.18</u>
			\$3710.81

Beginning Balance + Income - Outgo = Ending Balance

$$\$4279.11 + \$2549.70 - \$3710.81 = \$3118.00$$

The net loss for the Annual Fund in 1999 is \$1161.11.

1999 Annual Dues Summary:

Student,	10 x 1 yr	\$50.00
Individual,	61 x 1 yr	\$610.00
	4 x 2 yr	\$80.00
	1 x 3 yr	\$30.00
Family,	15 x 1 yr	\$180.00
Institutional,	10 x 1 yr	\$200.00
Obsolete Rates,	1 x 1 yr	<u>\$10.00</u>
	Total	\$1160.00

Life Member Fund Summary:

	<u>Income</u>	<u>Outgo</u>
98 Life Dues	\$360.00	none
½ Annual Payment	\$250.00	
Donation	\$150.00	
Interest	<u>\$143.65</u>	
Total	\$903.65	

Beginning Balance + Income - Outgo = Ending Balance

$$\$4865.03 + \$903.65 - \$0.00 = \$5768.68$$

The starting 1999 LMF target sum of \$6660.00 less the year-end balance of \$5768.68 leaves the LMF \$891.32 short of being fully funded. Two new life members volunteered in late 1999, too late to augment the LMF CD account within the year. Their dues will join the LMF CD at

its next maturity date in January 2000. Adding two new members, with no losses, sets the LMF target sum ahead \$360.00 at year's end, to \$7020.00.

Respectfully Submitted,

R. Fenstermacher

R. Fenstermacher, Treasurer

June 18, 2000

Hawaiian Botanical Society
3190 Maile Way
c/o Botany Department, University of Hawaii
Honolulu, HI 96822

Re: Hawaiian Botanical Society accounts audit

To Whom It May Concern:

I have reviewed the account books and treasurer's report for the Hawaiian Botanical Society for the calendar year 1999. I have found the books and the report to be detailed and mathematically accurate.

Respectfully,

Jonel L. Smith

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**NEWSLETTER OF THE HAWAIIAN BOTANICAL SOCIETY
C/O DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII AT MANOA
3190 MAILE WAY
HONOLULU, HI 96822**

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