DAVIS EXPEDITION FUND

REPORT ON EXPEDITION/PROJECT

Expedition/Project Title: Identification Keys to the grass genera of Belize.....

Travel Dates: 9th July-5th August.....

Location: Belize, Missouri Botanical Garden & New York Botanic Garden .....

Group Members: Steven Sylvester.....

Aims: To create both a computer based multi-access identification key and a printed dichotomous identification key to the grass genera of Belize .....

OUTCOME (not less than 300 words):-

I have attached a report on the project with both the printed dichotomous key and a DVD containing the multi-access key.

REPORT: Identification Keys to the Grass Genera of Belize

Steven Sylvester

Chapter 1. Introduction

The initial idea for this project stemmed from the many exasperating days spent in Belize during the Royal Botanic Garden Edinburgh (RBGE) MSc fieldtrip, January 2009, trying desperately to identify specimens of grass using the literature of Swallen (1955) and Davidse et al. (1994). As not one positive identification was made during the whole fieldtrip it was decided that Belize needed a better identification key for its grasses. The primary aim of this project has, thus, been the creation of both a computer based multi-access key and a printed dichotomous key to identify the grasses of Belize that are more user- friendly than previous keys for the country and use characters that are easily seen in the field. The keys produced were then tested and used to produce a preliminary checklist to the grasses of the Deep River Forest Reserve, Belize.

Chapter 2. Materials and Methods

2.1 Overview

Two initial diagnostic keys were produced from herbarium studies; A single-access dichotomous bracketed key and a computer based multi-access key using both DELTA INTKEY® (2009) and LUCID3 (Lucidcentral, 2009) software. Subsequent herbarium studies and fieldwork in Belize were done to test the keys and make alterations before the final keys were produced.

2.2 Herbarium Studies and Testing

The characters for the grass genera were scored from herbarium specimens and digital photographs eg. Tropicos (2009); GBIF (2009), as well as literature. Most of the specimens studied belonged to the Royal Botanic Garden Edinburgh (E) herbarium and trips were also made to other herbaria. Visits to other herbaria included a 5 day stay at the Royal Botanic Gardens, Kew (K), 7 days spent at the Missouri Botanical Garden (MO) and 3 days spent at the New York Botanic Garden herbarium (NY). The dichotomous and multi-access keys were tested using both indetermined Belizean grass specimens in the RBGE herbarium and determined specimens of Belizean taxa from RBGE and the other herbaria visited during the project. Staff and students from RBGE were asked to use both keys to identify specimens and any errors were noted to be corrected.

2.3 Fieldwork in Belize

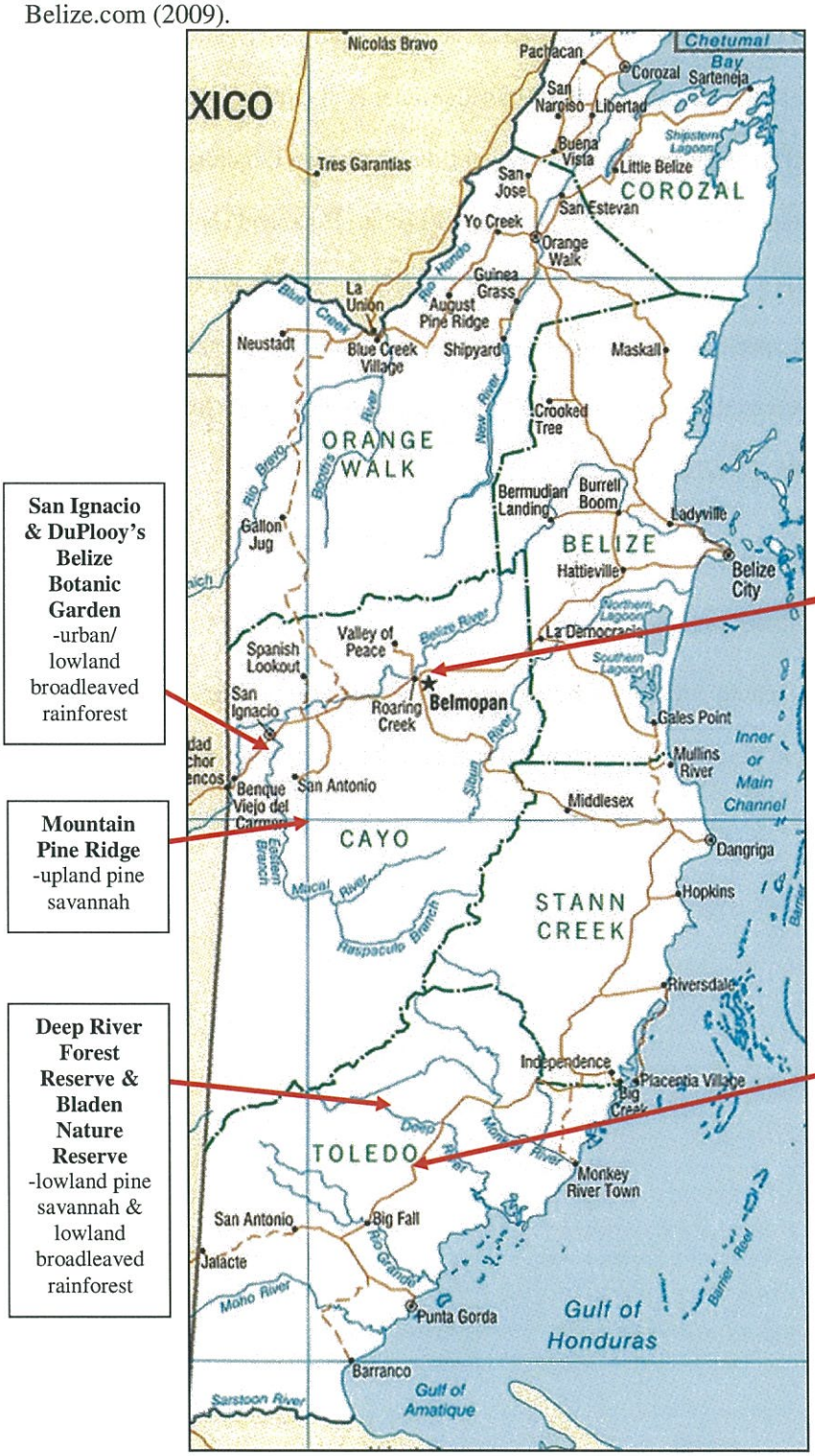
The fieldwork component was crucial in order to test out the created keys and correct for any errors. Intense fieldwork was conducted in Belize over 2 weeks between July 17th - July 31st 2009. The study covered a range of habitats present in Belize including lowland savannah of the Deep River Forest Reserve and the upland savannah of Mountain Pine Ridge. Lowland broadleaved rainforest and riverine habitats were also surveyed in Bladen Nature Reserve, Golden Stream Village and DuPlooys Belize Botanic Garden (BBG, 2009). Species were also identified from the urban areas of Belmopan, San Ignacio and Golden Stream Village. Fig. 1 below shows a map of all the areas and habitats visited and studied during the fieldwork.

The wide patrolling technique (*sensu* Ratter et al. 2003) was used to collect all grasses possible during the research period. For every species identified 3 voucher specimens were pressed and dried. GPS coordinates and qualitative vegetation descriptions were also recorded for each site. Vegetative characters that would be lost or become dubious on the specimens through the drying and mounting process were also recorded. This included:-

a) plant habit (whether rhizomatous, tufted etc.)
b) plant height (if whole specimen could not be placed on a sheet)
c) ligule characters
d) blades folded or rolled in the shoot
e) blade keeled
f) culm internodes hollow or solid
g) culm flattened or cylindrical
h) sheathes keeled or rounded

The majority of testing was done on the dichotomous key with only a few specimens being keyed out using the multi-access key due to the lack of a power supply for the laptop computer. The vegetative characters recorded were cross checked on the multi-access key software once back in the RBGE herbarium to see whether their were any discrepancies.

Figure 1, Overview map of areas visited during fieldwork. Taken from Freedom-In-Belize.com (2009).



San Ignacio & DuPlooy's Belize Botanic Garden
-urban/ lowland broadleaved rainforest

Belmopan
-urban

Mountain Pine Ridge
-upland pine savannah

Deep River Forest Reserve & Bladen Nature Reserve
-lowland pine savannah & lowland broadleaved rainforest

Ya'axche Conservation Trust Field Centre, Golden Stream Village
-urban/lowland broadleaved rainforest

Chapter 3. Results

389 specimens were studied that included all 78 genera and 257 species currently recorded from Belize (Balick et al. 2000; Bridgewater et al. 2006). Of those 389 specimens, 153 were studied from The Royal Botanic Garden Edinburgh (E), 47 from The Royal Botanic Garden Kew (K), 142 from Missouri Botanical Gardens (MO), and 25 from the New York Botanic Garden (NY). It was not possible to see specimens of 1 species, *Rhipidocladum bartlettii*, and so all the characters for this species were scored from Tropicos (2009) images and the literature (Swallen, 1955; Grassbase, 2009; Davidse et al. 1994).

3.1 The Keys

3.1.1 The Dichotomous Key

The complete dichotomous key is found below. An illustrated glossary was also produced to help the user in the identification process and can be found in the main thesis.

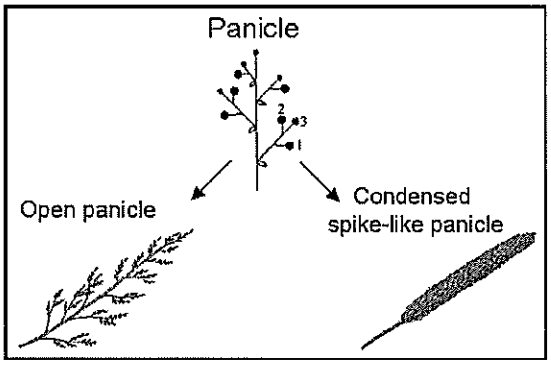
Identification Key to the Grass Genera of Belize

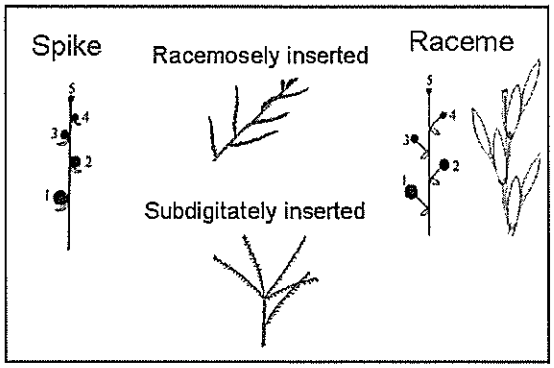
This key has been created for the genera and species listed in the Checklist of the Vascular Plants of Belize (Balick et al. 2000) and a few additional species found from a survey done by Bridgewater et al. (2006). No cultivated species have been included and for a list of the 5 species under cultivation please refer to Balick et al. (2000). The number in square brackets, eg. [1], of each couplet refers to the preceding question that led to that couplet so that a person may retrace their progress through the key. Where a few species have been keyed out separately within a genus the species epiphets have been included. For species and genera descriptions see Swallen (1955) and Davidse et al. (1994). The two lowest sterile bracts will be termed as the lower and upper glume even when, in certain genera, one of the actual glumes has been lost to be replaced by a sterile lemma. To use the key a x10 hand lens and ruler are needed as well as a dissecting needle for peeling back the glumes of certain taxa. Illustrations supplied courtesy of Hatch et al. (1999), Hickey & King (2000) and Görts-van-Rijn & Judziewicz (1990).

Master Key

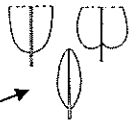
1 Spikelets held in a panicle (at least in the uppermost inflorescence); panicle either open, contracted or condensed and spike like.....**Sub-Key 1**
- **Spikelets held in a spike or raceme**; spikes/racemes either solitary, digitate/subdigitate, or inserted racemosely or in a panicle on the main axis.....2

2 Spikelets held on both sides or all around the rachis.....**Sub-Key 2 (Page 13)**
- Spikelets held on one side of the rachis.....**Sub-Key 3 (Page 17)**



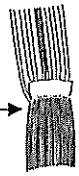


Sub-Key 1



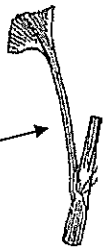
Spikelets held in a panicle (at least in the uppermost inflorescence); panicle either open, contracted or condensed and spike-like.

1 Leaf blade base cordate, pseudopetiolate or rounded abruptly before joining the sheath, blade base usually more than twice as wide as the sheath, if blade base narrow then leaves elliptical/obovate.....2
- Leaf blade base narrow and merging with the sheath, leaves linear, never elliptic.....20



2 [1] Woody bamboos 400-1500cm tall, stems with spines; spikelets composed of many sterile bracts at base of 5-8 fertile florets; spikelets 50-130mm long.....*Guadua longifolia*
- Plants herbaceous, usually shorter than 400cm, stems lacking spines; spikelets with 2-3 sterile bracts below single fertile floret; spikelets less than 10mm long.....3

3 [2] Inflorescence contracted into a dense spike-like cylinder; plant growing in and around rivers and lakes.....*Hymenachne amplexicaulis*
- Inflorescence an open panicle; plants found in a variety of habitats, rarely aquatic.....4



4 [3] Leaf blades without pseudopetioles or pseudopetioles less than 5mm long.....5
- Leaf blades with pseudopetioles longer than 5mm.....12

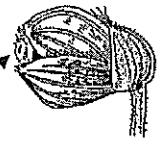
5 [4] Spikelets usually less than 8.5mm long, all of one type, not differing morphologically; leaf blades rarely pronouncedly asymmetrical.....6
- Large pistillate spikelets 8.5-34mm; spikelets of two distinct types on the same plant, staminate spikelets smaller and more slender, reduced to a lemma and palea; leaf blades asymmetrical.....13

6 [5] Glumes unequal in length, lower glume shorter than upper glume.....7
- Glumes equal in length, lower glume as long as upper glume.....15

7 [6] Spikelet midribs prominently keeled either for their entirety or just towards the tips.....8
- Spikelet midribs lacking prominent keels.....9

8 [7] Glume apices acuminate to awned; midrib of both glumes with a prominent keel running for the entirety of the glume.....*Ichnanthus (8 spp.)*
- Glume apices blunt to acute, never acuminate or awned; Glumes and upper fertile lemma with a keel towards the tip, the lower part rounded.....*Acroceras zizanoides*

9 [7] Glumes, lemmas and/or paleas with woolly hairs arising from the tips; fruits shiny black when mature; spikelets generally large, >3.5mm long, rarely as short as 2.6mm, placed obliquely on the pedicels, sub-globose; lower glumes 5-11-nerved; upper glume and lower lemma 7-13-nerved.....*Lasiacis (10 spp.)*



- Glumes, lemmas and/or paleas without woolly hairs arising from the tips; fruits green to purple when mature; spikelets generally small, <3mm long, rarely longer, erect on the pedicels, globose to lanceolate; lower glumes generally 0-3-nerved, rarely 5-nerved; upper glume and lower lemma generally 1-5-nerved, rarely 6-9-nerved.....10

NB. The woolly hairs in Lasiacis can sometimes be short and indistinct so many spikelets should be checked.

10 [9] Fertile lemma surface rugulose with fine wrinkles.....11
- Fertile lemma surface smooth and shiny.....*Panicum (33 spp.) & Dichanthelium (9 spp.)*

11 [10] Inflorescence a true panicle; spikelets solitary, elliptic-lanceolate, narrowed to an acute apex.....*Panicum trichoides/ P. maximum/ P. sellowii*
- Inflorescence a false panicle of short open racemes; spikelets in pairs, triplets or up to five with pedicels emerging from the same point on the rachis, rarely solitary; spikelets obovoid with a short acute apex.....*Urochloa fasciculata/ U. fusca*

12 [4] Leaf blade venation pinnate, cross veins between the obliquely diverging main veins; spikelets paired, of two distinct types differing morphologically, sessile pistillate spikelets larger than pedicellate staminate ones, 12-19mm long.....*Pharus (3 spp.)*

- Leaf blade venation parallel to the midvein, no conspicuous cross veins between the main veins; spikelets of one type, not differing morphologically, 3-4mm long.....*Setaria paniculifera/ S. poiretiana*

13 [5] Inflorescence solely terminal; large pistillate spikelets with the glumes unequal, the lower glume much longer than the upper glume.....*Olyra (2 spp.)*
- Inflorescences emerging both terminally and axillary, axillary inflorescences racemose or paniculate; large pistillate spikelets with the glumes equal/subequal.....14

14 [13] Ligule usually conspicuous 1-5.5mm long, asymmetrical; pedicels not enlarged towards summit; fertile lemma gradually narrowed to a blunt tip; fruit never triangular or bony white.....*Cryptochloa strictiflora*
- Ligule short, 0.5-0.7mm, symmetrical; pedicels of pistillate spikelets enlarged towards summit; fertile lemma triangular with a truncate apex; fruit triangular, initially boney white turning mottled brown when mature.....*Lithacne pauciflora*

15 [6] Spikelets awned.....16
- Spikelets awnless.....17

16 [15] Spikelets laterally compressed; glumes less than half the length of the spikelet, prominently keeled and ridged; awns 7-50mm long.....*Oryza (2 spp.)*
- Spikelets dorsally compressed; glumes as long as the spikelet, enclosing the florets, lacking keels; awns 1-16mm long.....*Sorghum halepense*

17 [15] Spikelets elliptic-lanceolate, 4-8mm long; glumes enclosing the florets; glume tips acute/acuminate.....18
- Spikelets globose or elliptic, 1-2mm long; glumes enclosing or slightly shorter than florets, glume tips rounded/obtuse or acute.....19

18 [17] Plants 15-50cm tall; leaf blades 4-12cm long; stem internodes hollow; spikelets 6-8mm long.....*Homolepis aturensis*
- Plants 100-200cm tall; leaf blades 28-90cm long; stem internodes solid; spikelets 4-6mm long.....*Sorghum halepense*

19 [17] Glumes as long as the spikelet; hardened fertile floret single, enclosed by the glumes.....*Panicum trichidiachne/ P. hirtum*
- Glumes slightly shorter than spikelet; hardened fertile florets 2, both similar in shape, not fully enclosed by the glumes.....*Isachne (3 spp.)*

20 [1] Plants gigantic, 3-15m tall, stems woody throughout with solid internodes, 3-5cm thick at the base.....*Gynerium sagittatum*
- Plants usually shorter than 3m, if taller then stems up to 2cm thick at the base, usually with hollow internodes, never woody throughout.....21

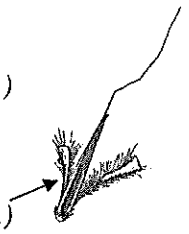
21 [20] Inflorescence a pseudopanicle interrupted by coloured spathes which subtend short racemes of paired sessile and pedicellate spikelets.....22
- Inflorescence lacking spathes; spikelets rarely paired in short racemes forming a pseudopanicle (and, if so, not subtended by spathes).....26

22 [21] Spikelets not subtended by hairs; pedicels minutely hairy/glabrous.....23
- Spikelets subtended by tufted hairs and/or pedicels covered with long hairs.....24

23 [22] Short annuals 4-60cm tall; leaf blades 1-3.5cm long; inflorescence a simple false panicle.....*Andropogon brevifolium*
- Tall perennials 95-165cm tall; leaf blades 10-50cm long; inflorescence a large false panicle.....*Hypogynium virgatum*

24 [22] Sessile spikelets with filamentous awns or awnless; if awned, awns glabrous or scabrid, exserted 5-17mm.....25
- Sessile spikelets with robust awns exserted 15-30mm, lower part of awns covered in short hairs .....*Hyparrhenia (2 spp.)*

25 [24] Internodes of rachis and pedicels slender throughout; lower glume midrib of sessile spikelet inwardly concave; lower glume apex acute; stem internodes usually hollow, rarely solid; sessile spikelets awned or awnless.....*Andropogon (9 spp.)*
- Internodes of rachis and pedicels with a prolonged slender base broadening to a large rounded apex; lower glume midrib of sessile spikelet outwardly convex or flat, never inwardly concave; lower glume apex bifid; stem internodes solid; sessile spikelets always awned.....*Schizachyrium (4 spp.)*



26 [21] Spikelets awnless, or if awned; awns less than 1mm long.....27
- Spikelets prominently awned; awns longer than 1mm.....44

27 [26] Spikelets subtended by tufted hairs or long stiff bristles and/or glumes covered with long/tufted hairs; pedicels sometimes with stiff bristles.....28
- Spikelets not subtended by tufted hairs or bristles; glumes not covered by long hairs; pedicels lacking bristles.....33

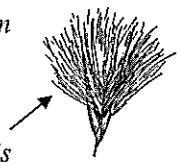
28 [27] Spikelets congested into a dense cylindrical false spike.....29
- Spikelets in an open panicle.....31

29 [28] Spikelets subtended by, and pedicels with, long stiff bristles; spikelets lacking long hairs.....*Setaria (8 spp.)*
- Spikelets and pedicels without long stiff bristles; spikelets subtended by long/tufted hairs and/or glumes covered with long hairs.....30

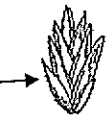
30 [29] Inflorescence hairs golden brown; stem nodes with tufted hairs.....*Eriochrysis cayannensis*
- Inflorescence hairs white; stem nodes hairless.....*Imperata (2 spp.)*

31 [30] Spikelets elliptic-lanceolate, dorsally compressed, hairs covering spikelets as long as 2mm, light or dark, never reddish, purple or silver; ligule a membrane, minute or conspicuous, 0.2-6mm long.....32
- Spikelets ovoid, laterally compressed; hairs covering spikelets as long as 8.5mm, reddish, purple or silver; ligule a ring of hairs c.1mm long.....*Rhynchelytrum repens*

32 [31] Spikelets paired, one sessile on the rachis the other pedicellate with pedicel emerging from the base of the sessile spikelet; ligule conspicuous 3-6mm long.....*Sorghum halepense*
- Spikelets solitary; ligule a minute ciliate membrane c.0.2mm long.....*Leptocoryphium lanatum*



33 [27] Spikelets 11- 20mm long, lanceolate; the rachilla between the fertile florets densely covered in long fine silky hairs giving a plumose appearance when flowering.....*Phragmites australis*
- Spikelets usually less than 10mm long, globose to lanceolate, if longer than 10mm the rachilla between the florets never covered in long silky hairs.....34



34 [33] Spikelets with three or more florets, conspicuously laterally compressed and keeled.....35
- Spikelets with one or two florets, laterally or dorsally compressed but never with prominent keels (*Leersia* is the only exception but is 1-flowered and lacks glumes.....36

35 [34] Glumes 3-7-nerved; lemmas 5-11-nerved; plants dioecious.....*Distichlis spicata*
- Glumes generally 1-nerved, rarely 3-nerved; lemmas 3-nerved; plants monoecious.....*Eragrostis (14 spp.)*

36 [34] Inflorescence congested into a solitary terminal dense cylindrical false spike 4-25cm long, 5-8mm wide.....37
- Inflorescence generally open to slightly congested but never a solitary terminal cylindrical false spike.....38

37 [36] Ligule an inconspicuous membrane 0.2-0.4mm long; glumes and lemmas membranous, 1-nerved.....*Sporobolus virginicus/ S. indicus/ S. jacquemontii*
- Ligule a conspicuous membrane, 1-2.5mm long; glumes and lemmas herbaceous, 3-7 nerved.....*Sacciolepis myuros*

38 [36] Spikelets held in two rows on one side of the rachis; spikelets 1-flowered; glumes missing with only a hardened lemma and palea present.....*Leersia (2 spp.)*
- Spikelets held on both sides or all around the rachis; spikelets 1- or 2-flowered; glumes present with all spikelets having more than 3 bracts.....39

39 [38] Glumes rarely as long as spikelet; spikelets laterally compressed (sometimes appearing dorsally compressed), midrib of glumes and lemmas usually keeled.....40
- At least 1 glume as long as the spikelet; spikelets dorsally compressed; midribs of glumes and lemmas rounded.....41

40 [39] Spikelets 2-flowered; glumes subequal, herbaceous; lemmas herbaceous, 3-nerved, scabrous on the keel.....*Eragrostis polytricha*
- Spikelets 1-flowered; glumes unequal, the lower glume shorter than the upper, membranous; lemmas membranous, 1-nerved, glabrous.....*Sporobolus (7 spp.)*

41 [39] Spikelets paired, one sessile on the rachis, the other pedicellate with the pedicel emerging from the base of the sessile spikelet; glumes equal, as long as the spikelet; fertile lemma never hardened.....*Sorghum halepense*
- Spikelets solitary, or if paired both spikelets pedicellate; glumes usually unequal, the lower shorter than the upper; fertile lemma distinctly hardened.....42

42 [41] Fertile lemma surface rugulose with transverse wrinkles.....43
- Fertile lemma surface smooth and shiny, rarely hairy (*P.discrepans*), never rugulose.....*Panicum (33 spp.) & Dichanthelium (9 spp.)*

43 [42] Inflorescence a true panicle; spikelets solitary, elliptic-lanceolate, narrowed to an acute apex.....*Panicum maximum*
- Inflorescence a false panicle of short open racemes; spikelets in pairs, triplets or upto five with pedicels emerging from the same point on the rachis, rarely solitary; spikelets obovoid with a short acute apex.....*Urochloa fasciculata/ U. fusca*

44 [26] Lemmas 3-awned.....*Aristida (10 spp.)*
- Lemmas 1-awned.....45

45 [44] Perennials; spikelets over 3.5mm long.....46
- Annuals; spikelets less than 2.5mm long.....50
NB. Spikelets can sometimes appear shorter than 3.5mm due to the long acuminate tips which can be misinterpreted as awns.

46 [45] Spikelets dorsally compressed or terete; glumes more than half the length to exceeding the spikelet; lemma surface smooth and without a keel on the midrib.....47
- Spikelets conspicuously laterally compressed; glumes less than half the length of the spikelet; lemmas distinctly ridged with keel on the midrib.....*Oryza (2 spp.)*

47 [46] Spikelets elliptic to elliptic lanceolate, paired, one sessile on the rachis, the other pedicellate with the pedicel emerging from the base of the sessile spikelet (in *Sorghastrum* the pedicellate spikelet is fallen with only the pedicel remaining); ligule a distinct membrane, 1.5-6mm long.....48
- Spikelets lanceolate, solitary; ligule an indistinct membrane, less than 0.6mm long.....49

48 [47] Pedicellate spikelets well developed, similar to the sessile spikelets but awnless, staminate; stem internodes solid.....*Sorghum halepense*
- Pedicellate spikelets absent with only the pedicels remaining or reduced to sterile rudiments; stem internodes hollow.....*Sorghastrum setosum*

49 [47] Spikelets 1-6mm long; sheathes hairy; glumes unequal in length, upper glume much longer than the lower, exceeding the spikelet.....*Arundinella (2 spp.)*
- Spikelets 15-23mm long; sheathes glabrous; glumes equal/subequal in length, shorter than the spikelet.....*Aristada ternipes*

50 [45] Plants over 60cm tall; spikelets with 3 bracts below the fertile floret ie. 2-flowered; glumes unequal, lower glume much shorter than upper glume; plants sticky with a characteristic strong sweet smell.....*Melinis minutiflora*
- Plants less than 30cm tall; spikelets with 2 bracts below the fertile floret ie. 1-flowered; glumes equal in length; plants not sticky or strong smelling.....*Muhlenburghia tenella*

Sub-Key 2

Spikelets in a spike or raceme and held on both sides or all around the rachis; spikes/racemes either solitary, digitate/subdigitate, racemosely inserted on the main axis or in a panicle.

1 Spikes/racemes solitary or digitate/subdigitate mostly arising from a central point on the peduncle.....2
- Spikes/racemes arranged racemosely or held in a panicle.....21

2 [1] Spikelets (at least the lower) sunk into the swollen rachis of the spike.....3
- Spikelets all free on the rachis.....5

3 [2] Spikelets all sunk into the rachis.....4
- Spikelets of two distinct types separate on the spike with lower spikelets sunk into the rachis whilst upper spikelets are free.....*Tripsacum (3 spp.)*

4 [3] Leaf sheaths glabrous, strongly keeled; leaf blades glabrous with a rounded apex, plants stoloniferous.....*Stenotaphrum secundatum*
- Leaf sheaths strongly papillose-hirsute (hairs irritating to touch), rounded; leaf blades with hairs present and an acute apex, plants tufted.....*Rottboellia cochinchinensis*

5 [2] Spikelets hidden inside a subtending spiny or spineless involucre.....6
- Spikelets free on the rachis and not subtended by an involucre.....7

6 [5] Involucre spiny.....*Cenchrus (3 spp.)*
- Involucre not spiny.....*Anthephora hermaphrodita*

7 [5] Spikelets awnless, or if awned, awns less than 1mm long.....8
- Spikelets (at least some) prominently awned, awns >1mm long.....14

8 [7] Spikelets subtended by long hairs/bristles and/or pedicels, if present, covered in long hairs.....9
- Spikelets not subtended by long hairs/bristles; pedicels, if present, glabrous.....12

9 [8] Inflorescence a congested terminal spike/raceme; spikelets solitary or, if paired, both pedicellate.....10
- Inflorescence 2-5 digitate racemes; spikelets paired, one sessile on the rachis, the other pedicellate, the pedicel emerging from the base of the sessile spikelet (sometimes the pedicellate spikelet is reduced with only the pedicel remaining).....*Andropogon selloanus/ A. leucostachys/ A. lateralis*

10 [9] Spikelets covered with long fine white hairs, 7-13mm long.....*Imperata (2 spp.)*
- Spikelets usually glabrous or rarely with short hairs; spikelets subtended by long yellow-purple bristles.....11

11 [10] Spikelets less than 3mm long, plano-convex, ovate-elliptic; rachis with long bristles attached.....*Setaria (8 spp.)*
- Spikelets more than 3.7mm long, terete, lanceolate; rachis without bristles.....*Pennisetum (3 spp.)*

12 [8] Spikelets of two distinct types in pairs on the spike/raceme, one a rugose ball, the other dorsally compressed; sheaths hairy.....*Hackelochloa granularis*
- Spikelets all similar; sheaths glabrous.....*13*

13 [12] Leaf blades narrow, 2-5mm wide; blade base narrow, merging with the sheath; spikelets 1-2mm long.....*Sacciolepis myuros*
- Leaf blades broad, 12-38mm wide; blade base cordate; spikelets 3-6mm long.....*Hymenachne amplexicaulis*

14 [7] Leaf blades broad, width ≥10mm, base cordate/rounded abruptly before joining the sheath.....15
- Leaf blades narrow, width 1- 5mm, base merging with the sheath, not rounded.....16

15 [14] Inflorescence digitate/subdigitate; awns bent, 5-10mm long; spikelets 4-7mm long; leaf blade base rounded abruptly before joining sheath.....*Ischaemum latifolium*
- Inflorescence a single spike; awns spirally twisted, 30-40mm long; spikelets 13-17mm long; leaf blade base abruptly narrowed into a pseudopetiole.....*Streptochaeta sodiroana*

16 [14] Awns 4-10cm long, thickened and hairy.....*Heteropogon contortus*
- Awns less than 2cm long, filamentous, scabrid or glabrous.....17

17 [16] Spikelets solitary, laterally compressed; glumes shorter than the spikelet, awned.....*Pentarrhaphis scabra*
- Spikelets paired, 1 sessile and 1 pedicellate, dorsally compressed; lower glume as long as/longer than the spikelet; glumes awnless.....18

18 [17] Stem nodes with tufted white hairs; awns 14-20mm long.....19
- Stem nodes hairless; awns <11mm long.....20

19 [18] Sheaths rounded, glabrous; glumes never with pitted holes.....*Dichanthium annulatum*
- Sheaths keeled, usually hairy; glumes usually with pitted holes in their centre.....*Bothriochloa pertusa*

20 [18] Stem internodes flattened, solid; ligule a short membrane 0.5-1mm long; racemes singular per peduncle; lower glume apex bifid; fertile lemma of sessile spikelet with ciliate margins, apex bifid.....*Schizachyrium tenerum/ S. sanguineum*
- Stem internodes cylindrical, usually hollow, rarely solid; ligule a ciliate membrane 1-2.5mm long; racemes 1-6 per peduncle; lower glume apex acute; fertile lemma of sessile spikelet with entire margins, apex acute.....*Andropogon lateralis/ A. gerardii*

21 [1] Inflorescence a panicle of short racemes subtended by coloured spathes; spikelets paired, one sessile on the rachis the other pedicellate (or fallen with only pedicel remaining).....22
- Spikes or racemes arranged racemosely or in a panicle, never subtended by spathes; spikelets either solitary and sessile on the rachis or, if paired in a false panicle of racemes, racemes never subtended by spathes.....26

22 [21] Spikelets not subtended by hairs; pedicels minutely hairy/ glabrous.....23
- Spikelets subtended by tufted hairs and/or pedicels covered with long hairs.....24

23 [22] Short annuals, 4-60cm tall; leaf blades 1-3.5cm long; inflorescence a simple panicle.....*Schizachyrium brevifolium*
- Tall perennials, 95-165cm tall; leaf blades 10-50cm long; inflorescence a large false panicle.....*Hypogynium virgatum*

24 [22]Sessile spikelets with filamentous awns or awnless; if awned, awns glabrous or scabrid, exserted 5-17mm.....25
- Sessile spikelets with robust awns exserted 15-30mm, lower part of awns covered in short hairs .....*Hyparrhenia (2 spp.)*

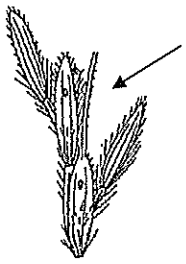
25 [24] Rachis internodes and pedicels slender throughout; lower glume midrib of sessile spikelet inwardly concave; lower glume apex acute; stem internodes usually hollow, rarely solid; sessile spikelets awned or awnless.....*Andropogon (9 spp.)*
- Rachis internodes and pedicels with a prolonged slender base which broadens to a large rounded apex; lower glume midrib of sessile spikelet outwardly convex or flat, never inwardly concave; lower glume apex bifid; stem internodes solid; sessile spikelets always awned.....*Schizachyrium (4 spp.)*

26 [21] Spikelets (or sessile/subsessile spikelets if spikelets paired) dorsally compressed, lacking prominent keels on the midrib, usually subtended by tufted hairs (rarely glabrous in *Sorghum halapense & Bothriochloa pertusa*).....27
- All spikelets laterally compressed with the glume midrib keeled, never subtended by tufted hairs.....31

27 [26] Inflorescence hairs dense, golden brown, obscuring the pedicels and rachis; inflorescence congested into a dense spike-like cylinder.....*Eriochrysis cayannensis*
- Inflorescence hairs white, dark, or lacking, never golden-brown, never so dense as to obscure the pedicels and rachis; inflorescence never congested into a dense solitary cylinder.....28

28 [27] Pedicellate spikelets well developed, similar to the sessile/subsessile spikelets but staminate or sterile.....29
- Pedicellate spikelets absent with only the pedicels remaining, or reduced to sterile rudiments less than 1mm long.....*Sorghastrum setosum*

29 [28] Pedicellate spikelets awned and laterally compressed; leaf blade base rounded abruptly before joining the sheath .....*Ischaemum latifolium*
- Pedicellate spikelets awnless and dorsally compressed; leaf blade base either merging with the sheath or rounded abruptly.....30

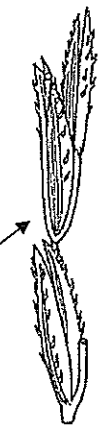


30 [29] Inflorescence racemes distinct, 3-28cm long, inserted racemosely on the central axis; glumes usually with a pitted hole in their centre; ligule a membrane indistinct to 1mm long; stem internodes hollow.....*Bothriochloa (2 spp.)*
- Inflorescence a false panicle with racemes indistinct, usually less than 3cm long; glumes never with pitted holes; ligule a membrane 3-6mm long; stem internodes solid.....*Sorghum halepense*

31 [26] Spikelets awned.....32
- Spikelets awnless 33

32 [31] Awns short, up to 2.2mm long; glumes shorter than the spikelet; leaf blade base merging with the sheath.....*Leptochloa virgata*
- Awns long, 7-25mm long; glumes as long as the spikelet; leaf blade base sub-cordate.....*Gymnopogon spicatus*

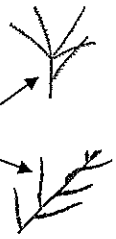
33 [31] Leaf blades broad, elliptic-ovate lanceolate, often pseudopetiolate; blade bases cordate or rounded abruptly before joining the sheath.....*Ichnanthus lanceolatus/ I. nemoralis*
- Leaf blades narrow, linear, without pseudopetioles; blade bases merging with the sheath.....34



34 [33] Inflorescence a panicle of verticillate racemes; spikelets paired, one sessile on the rachis the other pedicellate, the pedicel emerging from the base of the sessile spikelet; glumes covered in short scabrid spines.....*Vetiveria zizanoides*
- Inflorescence a panicle of alternate spikes; spikelets solitary and sessile on the rachis; glumes lacking spines.....*Leptochloa (3 spp.)*

Sub-Key 3

Spikelets in a spike or raceme and held on 1 side of the rachis; spikes/racemes either solitary, digitate/subdigitate, racemosely inserted on the main axis or in a panicle.



1 Spikes/racemes solitary or digitate/subdigitate, mostly arising from a central point.....2
- Spikes/racemes arranged racemosely or in a panicle.....23

2 [1] Spikelets (at least some) with awns.....3
- Spikelets awnless.....8

3 [2] Awns long, 2-10cm.....4
- Awns short, less than 0.6cm long.....5

4 [3] Awned spikelets 5-7mm long excluding the awn, awn 5-10cm long, twisted and bent, hairy .....*Heteropogon contortus*
- Awned spikelets 30-50mm long excluding the awn, awn 2-2.5cm long, straight, scabrose.....*Streptogyna americana*

5 [3] Plants woody and tall, 2-10m high, leaf blades petiolate; growing in rainforest.....*Rhipidocladum bartlettii*
- Plants herbaceous, less than 1m tall; leaf blades lacking petioles; growing in open areas.....6

6 [5] Spikes 1-3cm long; spike rachis terminating in a distinct naked green point.....*Dactyloctenium aegyptium*
- Spikes usually longer than 3cm; spike rachis not terminating in a naked point.....7

7 [6] Awns arising from between two lobes in the glume apex; glumes not membranaceous, green throughout; leaf blade apex obtuse.....*Eustachys petraea*
- Awns arising from the lemma tips and sometimes the glume tips; glumes with membranaceous margins; leaf blade apex acute to acuminate, rarely appearing obtuse.....*Chloris (3 spp.)*

8 [2] Spikelets (at least the lower) sunk into the swollen rachis of the spike.....9
- Spikelets all free on the rachis.....10

9 [8] Only the lower spikelets sunk into the swollen rachis of the spike, upper spikelets free on the rachis; plants huge, 300-600cm tall; leaf blade apex acute/acuminate; blade margins minutely toothed.....*Tripsacum (3 spp.)*
- All spikelets sunk into the swollen rachis of the spike; plants short, 10-35cm tall; leaf blade apex blunt/rounded; blade margins entire.....*Stenotaphrum secundatum*

10 [8] Plants herbaceous, less than 1.5m tall; leaf blades lacking pseudopetioles.....11
- Plants woody, over 2m tall; leaf blades pseudopetiolate.....22

11 [10] Spikelets subtended by tufted hairs.....12
- Spikelets not subtended by hairs.....13

12 [11] Sheath keeled; rachis covered with and spikelets subtended by stiff golden yellow-brown hairs; lower glume as long as spikelet.....*Axonopus aureus*
- Sheath rounded; spikelets subtended by white hairs; lower glume somewhat shorter than the spikelet.....*Mesosetum (2 spp.)*

13 [11] Spikelets dorsally compressed.....14
- Spikelets laterally compressed.....20

14 [13] Spikelets in a single row; rachis of the spike with well developed herbaceous wings partly enfolding the spikelets.....*Thrasya (2 spp.)*
- Spikelets in more than 1 row; rachis of spike rarely with herbaceous wings (cf.*Paspalum)*.....15

15 [14] Spikelets solitary on the rachis.....16
- Spikelets paired or in triplets, the pedicels all emerging from the same place on the rachis.....19

16 [15] Spikelets 4.5-6.7mm long; lower glume winged with a cordate base, glabrous; the upper glume strongly pustulose ciliate with cilia to 2mm long.....*Paspalum pectinatum*
- Spikelets rarely as long as 4.5mm and, if so, glumes never winged or with cordate bases; glumes never strongly pustulose ciliate.....17

17 [16] Spikelets 5.5-11mm long, lanceolate; glume apex acuminate; lower glume usually exceeding the spikelet and longer than the upper glume.....*Echinolaena gracilis*
- Spikelets less than 5mm long, ovoid to lanceolate; glume apex blunt or acute; lower glume never longer than the upper glume.....18

18 [17] Spikelets not distinctly plano-convex, both sides flattened to some degree; spikelets oblong-elliptic to elliptic-lanceolate, more than twice as long as wide; fertile lemmas facing away from the rachis; sheaths always keeled.....*Axonopus (6 spp.)*
- Spikelets distinctly plano-convex, flattened on 1 side with the other distinctly rounded; spikelets usually ovoid, less than twice as long as wide, sometimes elliptic; rounded fertile lemmas facing towards the rachis, flattened side of the spikelet facing away from the rachis; sheathes sometimes keeled.....*Paspalum (34 spp.)*

19 [15] Spikelets elliptic-lanceolate, not distinctly plano-convex; glumes narrowed to an acute tip; fertile lemma surface gristly, finely wrinkled; margins of the fertile lemma thin/hyaline, thinner than the main body of the lemma, not inrolled.....*Digitaria (7 spp.)*
- Spikelets ovoid/elliptic, distinctly plano-convex; glumes either with a short acute tip or apex blunt; fertile lemma surface smooth, margins thick or herbaceous, not thinner than the main body of the lemma, inrolled around the palea.....*Paspalum (34 spp.)*

20 [13] Spikelets 1-3mm long, 1-flowered.....*Cynodon (2 spp.)*
- Spikelets 4-11mm long, 2-many-flowered.....21

21 [20] Spikes solitary, 2-2.5cm long; glumes longer than the spikelet, lower glume much longer than the upper.....*Echinolaena gracilis*
- Spikes usually 2-6, rarely solitary, usually 3.5-10cm long, rarely shorter than 2.5cm; glumes shorter than the spikelet, lower glume shorter than the upper.....*Eleusine indica*

22 [10] Stem diameter 20-35mm, nodes with a skirt of white hairs; spikelets 10-15mm long.....*Merostachys pauciflora*
- Stem diameter 2-8mm, nodes without a skirt of white hairs; spikelets 16-25mm long.....*Rhipidocladum bartlettii*

23 [1] Spikelets laterally compressed; glumes (or lemma if glumes absent) prominently keeled on the midrib.....24
- Spikelets dorsally compressed; glumes (or lemma if glumes absent) lacking a prominent keel.....32

24 [23] Spikelets awned.....25
- Spikelets awnless.....29

25 [24] Ligule a hairy ciliate membrane, 3-6mm long including the cilia; auricles present at the junction of the sheath and blade; plants over 1m tall.....*Oryza (2 spp.)*
- Ligule inconspicuous to 2mm long, sometimes ciliate, never hairy; sheaths lacking auricles; plants usually less than 1m tall.....26

26 [25] Spikes/racemes long and narrow, 5-25cm long.....27
- Spikes/racemes short and broad, less than 4cm long.....28

27 [26] Leaf blade base merging with the sheath; glumes shorter than the spikelet; awns arising from the tips of the lemmas, up to 2.2mm long.....*Leptochloa virgata*
- Leaf blade base subcordate; glumes as long as the spikelet; awns arising from the tips of the glumes and the lemmas, 7-25mm long.....*Gymnopogon spicatus*

28 [26] Spikelet 5-9mm long excluding awns; leaf blades linear, narrow, 1-4mm wide; Awns arising from the tips of the lemmas, lemmas 3-awned.....*Bouteloua repens*
- Spikelet 2-4.5mm long excluding awns; leaf blades elliptic, broad, 4-20 mm wide; awns arising from the tips of the glumes; glumes 1-awned.....*Oplismenus (2 spp.)*

29 [24] Leaf blades elliptic with a sub-cordate base, usually psuedopetiolate; both glumes as long as the spikelet with lower glume usually exceeding the spikelet.....*Echinolaena standleyi*
- Leaf blades linear, bases merging with the sheath; lowest glume (if present) shorter than the spikelet.....30

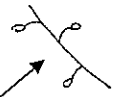
30 [29] Spikelets 2-9-flowered, with 4 or more bracts clearly visible; the uppermost floret reduced to a small rudiment.....*Leptochloa (3 spp.)*
- Spikelets 1-flowered, with 2-3 bracts visible; the floret never reduced.....31

31 [30] Glumes absent; spikelet consisting of a hardened lemma enclosing a hardened palea; lemma with long scabrid hairs on the keel; stem internodes hollow.....*Leersia (2 spp.)*

- Glumes present, unequal in length, lower glume shorter than the spikelet, keels with short scabrid hairs; stem internodes solid.....*Spartina spartinae*

32 [23] Glumes equal in length; solely 2 glumes enclosing fertile floret.....33
- Glumes unequal in length, lower glume shorter than upper glume; 2 glumes and sterile lemma enclosing fertile floret.....37

33 [32] Lemma much shorter than glumes (often difficult to see if enclosed by glumes), awned; awn stiff, 1mm long, arising from the lemma apex.....*Eriochloa punctata*
- Fertile lemma as long as glumes, never awned.....34



34 [33] Spikelets solitary on the rachis.....35
- Spikelets paired or in groups of 3-5, the pedicels all emerging from the same place on the rachis.....36

35 [34] Spikelets not distinctly plano-convex, both sides flattened to some degree; spikelets oblong-elliptic to elliptic-lanceolate, more than twice as long as wide; lower glume and fertile lemma facing away from the rachis; sheaths always keeled.....*Axonopus ciliatifolius/poiophyllus/purpusii/compressus*
- Spikelets distinctly plano-convex, one side flattened the other distinctly rounded; spikelets usually ovoid, less than twice as long as wide, rarely elliptic; lower glume and fertile lemma facing towards the rachis; sheaths sometimes keeled.....*Paspalum (34 spp.)*

36 [34] Spikelets elliptic-lanceolate, not distinctly plano-convex; glumes narrowed to an acute tip; lemma surface gristly, finely wrinkled; margins of the lemma thin/hyaline, thinner than the main body of the lemma; lemma margins not inrolled.....*Digitaria (7 spp.)*

- Spikelets ovoid/elliptical, distinctly plano-convex; glumes either with a short acute tip or apex blunt; lemma surface smooth, margins thick or herbaceous, not thinner than the main body of the lemma; lemma margins inrolled around the palea.....*Paspalum (34 spp.)*

37 [32] Lower glume developed, 1-5-nerved.....38
- Lower glume reduced to a nerveless rudiment.....44

38 [37] Both glumes as long as the spikelet with the lower glume longer than the upper glume, exceeding the spikelet in an acuminate tip; leaf blades psuedopetiolate.....*Echinolaena standleyi*
- Only the upper glume as long as the spikelet with the lower glume shorter than the upper glume, rounded to acute; leaf blades never pseudopetiolate.....39

39 [38] Sheaths prominently keeled; spikelets often awned, or rachis with long dark bristles.....40
- Sheaths usually rounded, rarely slightly keeled; spikelets never awned; rachis without bristles, or if bristles present then white and filamentous.....41

40 [39] Rachis of spike with long dark bristles attached; spikelets never awned; lemmas never hardened and shiny.....*Ixophorus unisetus*
- Rachis of spike without bristles; spikelets often awned; fertile lemma hardened and shiny.....*Echinochloa (3 spp.)*

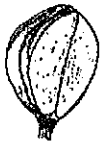
41 [39] Fertile floret surface gristly/rugulose with fine transverse wrinkles.....42
- Fertile floret surface smooth.....43

42 [41] Leaf blades symmetrical; lower glume 3-5-nerved.....*Urochloa (4 spp.)*
- Leaf blades asymmetrical; lower glume 1-nerved.....*Panicum sellowii*

43 [41] Rachis terminates in a reduced sterile spikelet or a short naked point/bristle.....*Paspalidium geminatum*
- Rachis terminates in a fertile spikelet.....*Panicum (33 spp.)*

44 [37] Leaf base cordate; fertile lemma surface finely wrinkled.....*Urochloa reptans*
- Leaf base merging smoothly with sheath or rounded, never cordate; fertile lemma surface never finely wrinkled.....45

45 [44] Spikelets ovoid/ellipsoid, distinctly plano-convex; glumes with a short acute tip or apex blunt; uppermost lemma surface smooth, margins thick, never thin/hyaline, inrolled around the palea.....*Paspalum (34 spp.)*



- Spikelets elliptic-lanceolate, rarely distinctly plano-convex; glumes narrowed to an acute tip; uppermost lemma surface gristly with wrinkles; margins of the uppermost lemma thin/hyaline, not inrolled.....*Digitaria setigera/insularis*

3.1.2 The Computer Based Multi-Access Key

A CD has been supplied with this report containing the computer based LUCID3 key. This key includes all the genera and species found in the dichotomous key and also includes the 3 extra genera and 5 species of cultivated grasses listed in Balick et al. (2000). A short instruction manual to using the LUCID3 Player can be found in Appendix 1 which highlights the main features of the program.

3.1.3 Testing and Modification of Keys

The initial keys created from herbarium studies were tested thoroughly in Belize and the various herbaria. 95 collections were made during the fieldwork with 30 genera and (possibly) 65 species being identified (see Table 1 and Appendix 2 for lists of the specimens collected and determined using the keys). No new species or genera were found to add to the checklist of Belize (Balick et al. 2000) during this trip although there are a number of specimens (eg. SPS 90 & 91) that have not been identified to the species level and may be new records for the country.

Testing of both keys in the field and using herbarium specimens led to a number of errors being noted which were consequently corrected. The vegetative characters recorded for each specimen collected in Belize (see section 2.3) differed somewhat from the characters scored on the multi-access key. It was found, right from the first specimens collected, that certain characters that were scored using literature sources as opposed to specimen study did not hold up when keying out the Belizean specimens. This included characters related to the ligule, the flattening of the culm and whether the culm internodes were solid/hollow which were too difficult to ascertain from herbarium specimens and so literature was relied upon.

It was unfortunate that many of the common savannah species were the most difficult to key out due to either their variability or their being an exception to the general form found in their genus. This included *Paspalum pectinatum* (Fig.4, A & B) which had large lanceolate spikelets strikingly different to the common distinctly plano-convex spikelet found in the genus. This species was found to be a common constituent of upland pine savannah and merited being keyed out separately from the rest of the *Paspalum* genus. *Heteropogon contortus* (Fig.4 C) also created problems as it was found in clumps with spikelets appearing unilateral whilst in other clumps the spikelets would appear distichous meaning that it had to be keyed out twice.

Subsequent herbarium studies at the Royal Botanic Garden Edinburgh herbarium found that not one of the specimens was incorrectly identified at the generic level. The only specimen where there was uncertainty over the generic determination was SPS 30 which was placed tentatively in either of the spathulate grass genera, *Schizachyrium* or *Andropogon*, and was later determined as *Andropogon glomeratus*. This specimen was not flowering and was keyed out using the multi-access key from the vegetative characters available.

3.2 Preliminary Checklist of the Grasses of the Deep River Forest Reserve

From thorough testing of the keys over the space of 4 days, in both the lowland pine savannah and the bordering lowland broadleaf forest, 43 collections were made and a total of 36 species from 20 genera were identified (see Table 1 below). No grasses were recorded that were new to the Checklist of Belize (Balick et al. 2000). The

rainforest grasses found on the boundary between Deep River Forest Reserve and Bladen Nature Reserve were included in the checklist. The largest diversity of grasses was found on edge habitats, including track margins and the transition zone between the pine savannah and broadleaved forest.

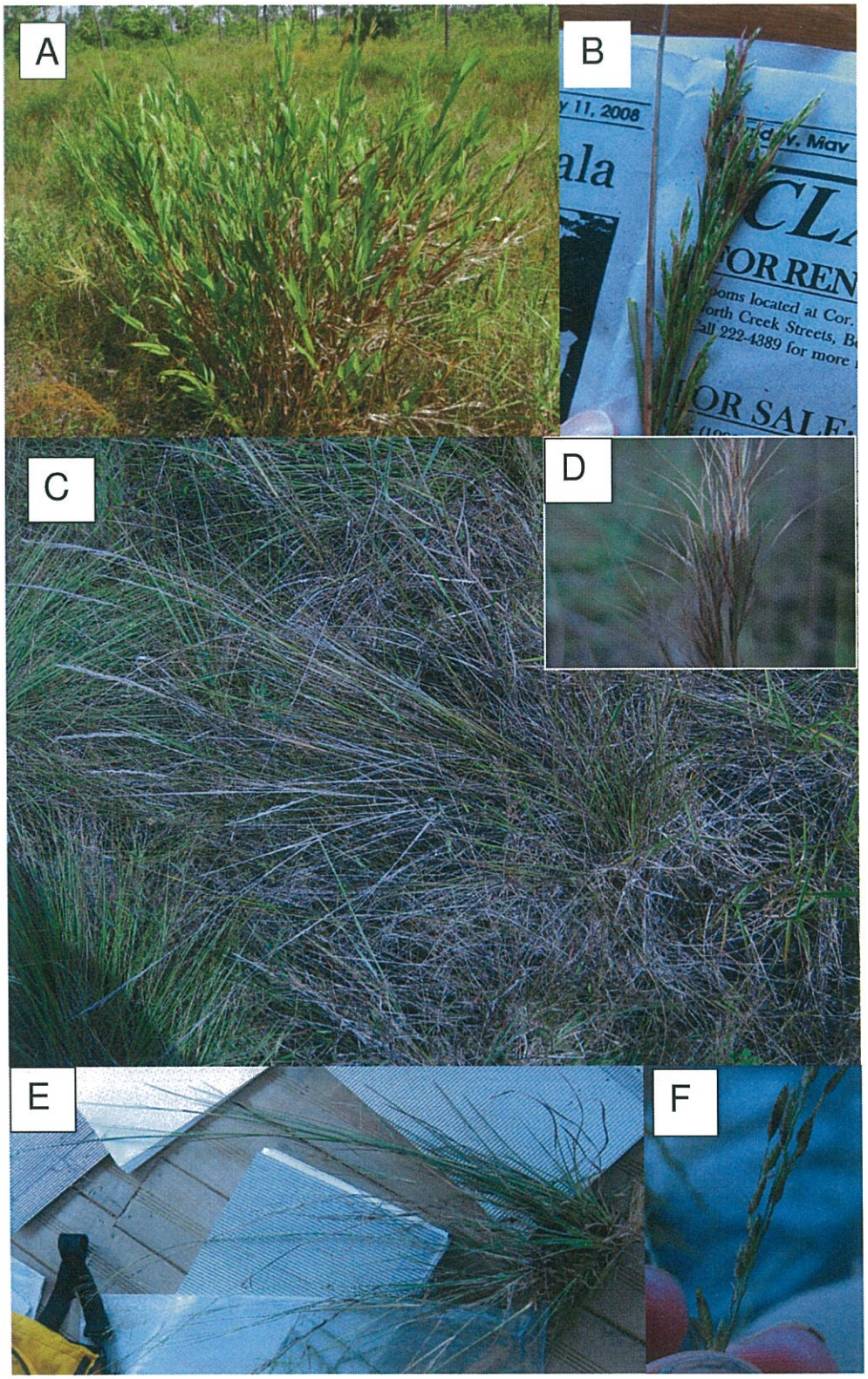
Figure 2, Bladen Nature Reserve ranger base located within Deep River Forest Reserve

It was found that, within the savannah and away from the tracks, *Aristida* needle grasses dominated (Fig.3, C-D). Wetter areas such as around pools and ditches were dominated by *Eragrostis atrovirens* and *Hypogynium virgatum* (Fig.3, E-F and B respectively). Another common conspicuous grass was *Ischaemum latifolium* which was locally dominant in patches throughout the savannah (Fig.3, A).

Table 1, Preliminary checklist of the grasses of Deep River Forest Reserve including data on the perceived abundance of the species within the habitat listed. R= Rare; O= Occasional; F= Frequent; C= Common; D=Dominant

Collector number	GENUS	Species epiphet	Habitat where plant collected and frequency of occurrence within habitat
SPS30, 48	*Andropogon*	*glomeratus*	C; Pine savannah
SPS25	*Andropogon*	*leucostachys*	O; Pine savannah
SPS45	*Andropogon*	*virginicus*	O; Pine savannah
SPS29, 44	*Aristada*	*appressa*	D; Damp pine savannah
SPS51	*Axonopus*	*aureus*	R; Damp pine savannah
SPS37	*Axonopus*	*fissifolius*	O; Pine savannah
SPS31	*Axonopus*	*poiophyllus*	O; Pine savannah
SPS24	*Axonopus*	*purpusii*	O; Pine savannah
SPS12, 33	*Dichanthelium*	*aciculare var. ramosum*	O; Lawn grass on fertile soil
SPS39	*Eleusine*	*indica*	O; Sandy riverbank
SPS16, 49	*Eragrostis*	*atrovirens*	C; Trackside, pine savannah
SPS13	*Eragrostis*	*mexicana*	O; Trackside, pine savannah
SPS38	*Gynerium*	*sagittatum*	C; River bank
SPS50	*Heteropogon*	*contortus*	R; Pine savannah
SPS15	*Homolepis*	*aturensis*	F; Trackside, pine savannah
SPS21	*Hypogynium*	*virgatum*	F; Damp area, pine savannah
SPS17, 20	*Ischaemum*	*latifolium*	C; Trackside, pine savannah
SPS19	*Leptochloa*	*virgata*	O; Trackside, pine savannah
SPS43, 52	*Mesosetum*	*blakei*	O; Damp pine savannah
SPS36	*Oryza*	*latifolia*	O; Trackside, lowland rainforest
SPS22	*Panicum*	*cyanescens*	C; Damp pine savannah
SPS32	*Panicum*	*parvifolium*	C; Pine savannah
SPS28	*Panicum*	*polygonatum*	O; Trackside, lowland rainforest
SPS27	*Panicum*	*rudgei*	O; Pine savannah
SPS40	*Panicum*	*trichoides*	C; Damp pine savannah
SPS46, 47	*Paspalum*	*clavuliferum*	O; Wet open ground
SPS10	*Paspalum*	*conjugatum*	D; Lawn grass on fertile soil
SPS35	*Paspalum*	*decumbens*	O; Trackside, pine savannah
SPS42	*Paspalum*	*minus*	R; Trackside, pine savannah
SPS26	*Paspalum*	*pectinatum*	R; Pine savannah
SPS14	*Paspalum*	*pilosum*	C; Trackside, pine savannah
SPS11	*Paspalum*	*plicatulum*	O; Lawn grass on fertile soil
SPS34	*Setaria*	*parviflora*	R; Trackside, pine savannah
SPS18	*Sporobolus*	*jacquemontii*	O; Trackside, pine savannah
SPS23	*Thrasya*	*campylostachya*	C; Trackside, pine savannah
SPS41	*Urochloa*	*fasciculata*	O; Trackside, lowland rainforest

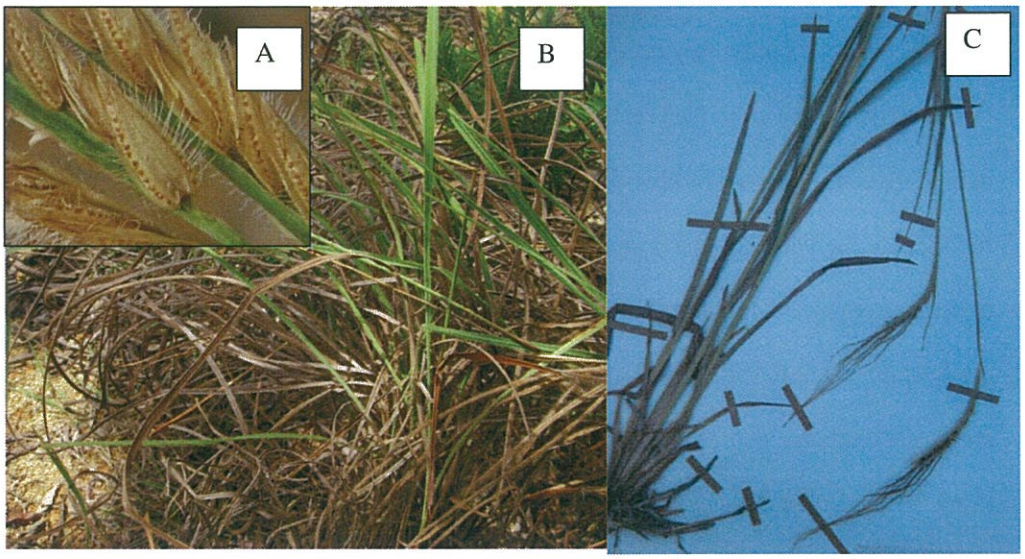
Figure 3, Dominant and common grasses of the Deep River Forest Reserve. A- *Ischaemum latifolium* (SPS, 20); B- *Hypogynium virgatum* (SPS, 21); C,D- *Aristida appressa* (SPS, 44); E,F- *Eragrostis atrovirens* (SPS, 49).



3.3 Common Grasses of Belize

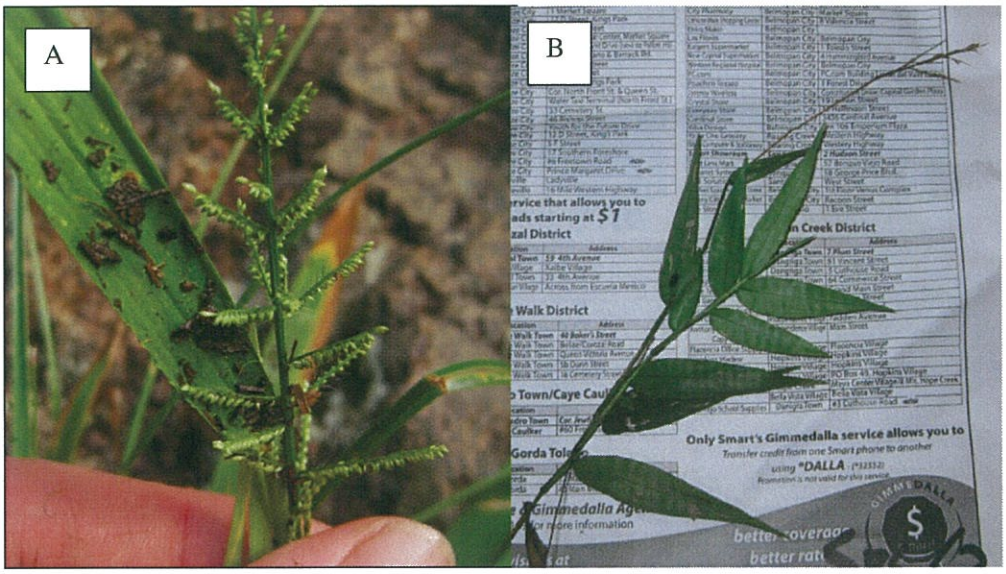
Overall, the most commonly encountered genus across the whole of Belize during the fieldwork was *Paspalum* (see section 4.1) which was found in abundance in every habitat visited. From the fieldwork the common constituents of each area visited were recorded to see what comparisons there would be between areas and habitats. The upland savannas at Mountain Pine Ridge (MPR) were distinctly different from that of the lowland Deep River Forest Reserve (see section 3.2 above) with a different species assemblage and different dominant species. Both *Heteropogon contortus* (SPS, 75) and *Paspalum pectinatum* (SPS, 84) were found to be dominant in areas such as that near Big Rock Falls and Pinol Sands. These species were found in sparse patches infrequently in Deep River Forest Reserve. Other parts of MPR were dominated by *Aristida appressa* (SPS, 94) as in Deep River Forest Reserve although *Aristida recurvata* (SPS, 78) and *Aristida setifolia* (SPS, 73) were also found frequently. Tracksides within both the upland and lowland savannas had a higher species diversity compared with the actual savannah which was dominated by a few species including those listed above. *Paspalum pilosum* (SPS, 80) and *Thrasya campylostachya* (SPS, 81) were found commonly in this environment as well as *Eragrostis atrovirens* (SPS, 16 & 13).

Figure 4, Common grasses of Mountain Pine Ridge. A & B-*Paspalum pectinatum* (SPS, 85); C-*Heteropogon contortus* (Reeder & Reeder, 2083 [E]).



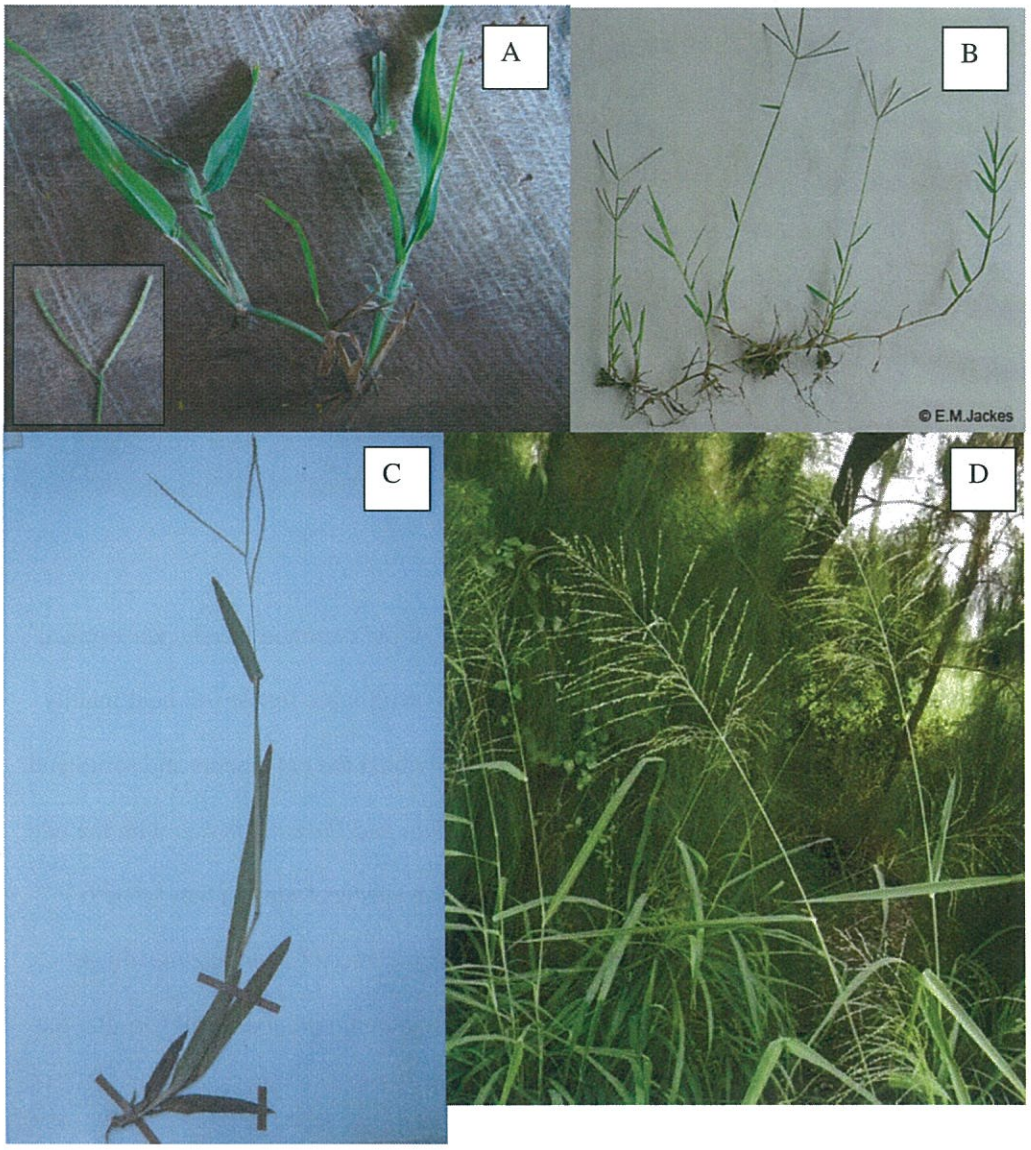
The rainforest areas were poor in grasses with species of *Ichnanthus tenuis* (SPS, 62 & 63) and *Panicum polygonatum* (SPS, 64) being the most frequently encountered although few were flowering to make an accurate determination possible. *Panicum polygonatum* was found in every habitat visited and could be viewed as a generalist that can survive in both waterlogged and drought stressed areas.

Figure 5, Common grasses found in the rainforest understorey. A-*Panicum polygonatum* (SPS, 89); B-*Ichnanthus tenuis* (SPS, 63).



Urban areas tended to be dominated by a mixture of the common weedy pan-tropical species. In Belize City and Belmopan, the gardens with more fertile soil held mainly *Paspalum conjugatum* and *Axonopus compressus* whilst the pavements and scrubland areas held mainly *Cynodon dactylon, Chloris inflata* and *Eleusine indica* with the odd clump of *Schizachyrium microstachyum.* The urban species found in San Ignacio differed from those of Belize City; there was an abundance of *Panicum maximum* (SPS, 97) as well as *Paspalum virgatum* with *Paspalum conjugatum* still forming the dominant species.

Figure 6, Common urban grasses. A-*Paspalum conjugatum* (SPS, 10); B-*Cynodon dactylon* (Taken from JCU, 2009); C-*Axonopus compressus* (Reeder & Reeder, 2068 [E]); D-*Panicum maximum* (Taken from Picasaweb, 2009); E-*Chloris inflata* (SPS, 61).



Chapter 4. Discussion of Fieldwork Observations

From the fieldwork the common constituents of each area visited were recorded to see what comparisons could be made between areas and habitats. Caution needs to be taken when applying these generalizations as only a small portion of the Belizean land area was visited during the fieldwork. Furthermore, the generalizations stated were made from only a 2 week time period and it is very likely that there will be different common species emerging at different times of the year. For example, not a single species of *Digitaria* was seen during the fieldwork yet at least one species, *D. horizontalis*, is known to be a common urban constituent (Ravi & Mohanan, 2002). The fieldwork was undertaken during the rainy season and it has been mentioned, from local correspondence, that there are more grasses flowering during the dry season which may be a better time to focus collection efforts in the future. Nevertheless, the work done has still painted a more informative picture of the common grasses likely to be encountered in Belize.

Most of the species encountered are found pan-tropically. Many are classed as common pan-tropical weeds (Ravi & Mohanan, 2002), especially those from urban areas, eg. *Paspalum conjugatum* (Fig.6), *Cynodon dactylon* (Fig.6), *Axonopus compressus* (Fig.6), *Eleusine indica, Echinochloa colona* (SPS, 67), *Rottboellia cochinchinensis* (SPS, 66) etc. Common constituents of the savannah flora were also found pan-tropical, eg. *Heteropogon contortus* (Fig.4), used by tribes in Ethiopia as a common thatching for houses (Ravi & Mohanan, 2002). *Paspalum pectinatum* (Fig.4) is found across South and Central America, extending from Paraguay and Brazil to Mexico (GBIF, 2009; Tropicos, 2009). There were certain dominant or common

savannah species collected that are only found within Central America including *Aristida appressa* (Fig.3) and *Mesosetum blakei* (SPS, 43,52) and (Tropicos, 2009).

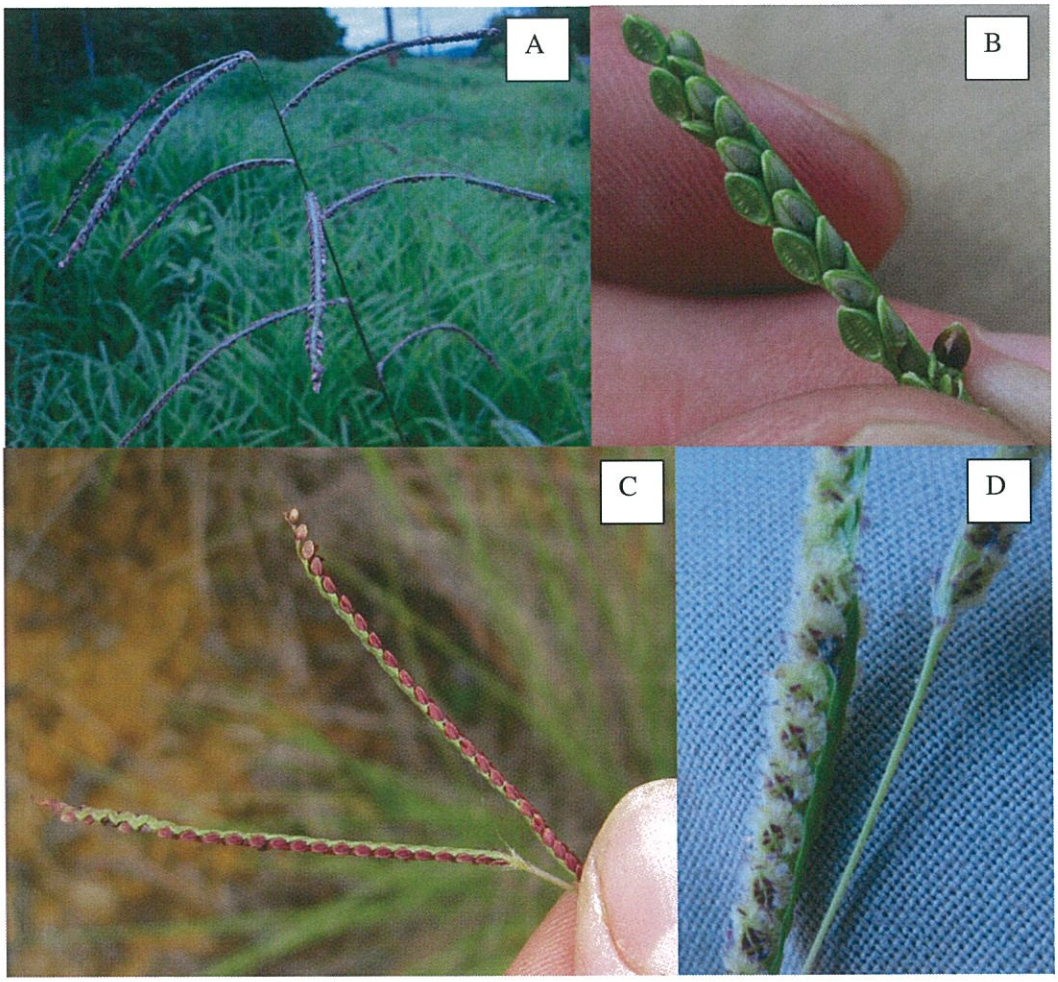
The differing species composition found between the upland and lowland savannas is most likely related to the soils. The upland savannas at Mountain Pine Ridge (MPR) are stated to be highly weathered nutrient poor soils of igneous and metamorphic origin (Balick et al. 2000). These soils are more freely draining than those of the lowlands where the soil is subject to varying durations of inundation during the wet season (Stuart et al. 2006). Similarly, the urban areas of Belize City, Belmopan and San Ignacio differed in their grass communities most likely a result of the differing soil fertility.

Tracksides were found to be the areas of highest diversity due to their being edge habitats and open to colonization by opportunist species. These accommodate many species that would not be able to get established amidst the dominant tufted savannah grasses due to their being outcompeted for nutrients and light (Olff, 1992; Wacker et al. 2008). The rainforest areas were poor in grasses due to the over-competition by woody species. The largest diversity of grasses was found on the tracks that were slightly open to sunlight. It also appears that the rainy season is not a good time to look at rainforest grasses as few if any were flowering and the dry season may afford better opportunity in finding these species.

4.1 Paspalum

This was found, overall, to be the most frequently encountered grass genus during the fieldwork. Once a person becomes familiar with the genus it can be recognized quite easily the whole way across Belize with only a small number of species that could be misinterpreted for the closely related Panicoid genera, *Axonopus* and *Digitaria.* It is quite distinctive amongst the Poaceae and all species bear similarities of having unilateral racemes with plano-convex spikelets, each spikelet having a hardened shiny fertile floret. The genus, as a whole is large with c.330 spp. (Mabberley, 2008) and is the most speciose grass genus in Belize with 34 species (Balick et al. 2000). Many of the *Paspalum* specimens encountered during the fieldwork could not be named to species as their descriptions did not match those of Davidse et al. (1994) with there being cross over in the descriptions between certain species. This is probably a consequence of the genus continuing to speciate with the boundaries between species becoming blurred.

Figure 1, Examples of *Paspalum* species found in Belize. A-*Paspalum virgatum* (SPS, 57), a common large grass found on moist banks; B- *Paspalum plicatulum* (SPS, 102), showing the distinct corrugations that characterize the species; C-*Paspalum* sp. (SPS, 79) yet to be identified to species; D-*Paspalum fimbriatum* (SPS, 68) with conspicuously winged glumes.



Chapter 5. Conclusion & Future Prospects

The dichotomous key was found to work much better at identifying specimens to genus compared with the multi-access key. The multi-access key, unfortunately, could not identify some of the commonest speciose genera due to their variability which overlapped with that of other genera. Nevertheless it is still a useful tool, especially for vegetative identification, and will help surveyors to narrow down the possibilities of what the specimen is that they are trying to identify.

In general, floral characters were found to be of greater value in grouping large numbers of genera compared with vegetative characters. This was due to the vegetative variability present within taxa meaning that there were few consistent vegetative characters available.The characters used were, for the most part, easily recognizable and understood. The dichotomous key bears little resemblance to the dichotomous keys produced for other Central American countries with more species specific, novel characters being used.

It is hoped that this project will be beneficial to future botanical work within Belize. Armed with both keys a field botanist should be able to identify the genus, and often species, of any grass specimen in any corner of the country. Work now needs to focus on expanding the keys to the species level for the country. A multi-access key to the species would eliminate many of the problems found in trying to key out the speciose genera which contain taxa with highly variable morphologies, eg. *Panicum*. A long term goal should be to produce a vegetative key to the common Belizean grasses. Part of the problem with this is that it is still unclear which grasses are common or not but these keys will hopefully work towards filling this gap in our knowledge.

Habitat classification for the Belizean savannas has been largely based on the woody species present with the grass component being overlooked. Within the savannas visited during this project it has been noted that there are definite distinctions in the grass communities. It may be that, with time, a more effective classification scheme will be developed which includes the grasses and these identification keys will be of real use in assisting this.

One interesting thought to mention is that, over the space of 4 days, a preliminary checklist of 36 grass species was compiled for Deep River Forest Reserve. In comparison with another, much larger study, for the Chiquibul Forest that covered a much wider diversity of habitats and was based on 7047 herbarium and live collections (Bridgewater et al. 2006) a checklist of only 55 grass species was compiled. This is not an isolated example with most studies done (eg. Bridgewater et al. 2002 [18 spp.]; Urban et al. 2006 [9 spp.]), covering much wider areas and more intensely than the present study, failing to identify a similar number of species. This highlights the lack of coverage of grasses in current surveys. The new keys produced are hoped to be the basis for improved surveys and a more in depth look at Belizean vegetation.

References

Balick, M.J.; Nee, M.H. & Atha, D.E. (2000) Checklist of the vascular plants of Belize, with common names and uses. *Memoirs of the New York Botanical Garden* **85**: 1-246.

BBG: DuPlooys Belize Botanic Garden. (2009) BBG Homepage. [www document] <http://www.belizebotanic.org/> (Accessed 18/08/09).

Bridgewater, S.; Ibanez, A; Ratter, J. & Furley, P. (2002) Vegetation classification and floristics of the savannas and associated wetlands of the Rio Bravo conservation and management area, Belize. *Edinburgh Journal of Botany* **59** (3): 421-442.

Bridgewater, S.; Harris, D.J.; Whitefoord, C.; Monro, A.K.; Penn, M.G.; Sutton, D.A.; Sayer, B.; Adams, B.; Balick, M.J.; Atha, D.H.; Solomon, J.B. & Holst,K. (2006) A preliminary checklist of the vascular plants of the Chiquibul Forest, Belize. *Edinburgh Journal of Botany* **63** (2-3): 269-321.

Davidse, G.; Mario Sousa, S. & Chater, A.O. (eds.) (1994) *Flora Mesoamericana Volumen 6: Alismataceae a Cyperaceae.* Universidad Nacional Autonoma de Mexico, Missouri Botanical Garden, The Natural History Museum (London). D.R., Mexico.

Freedom-in-Belize.com (2009) *Map of Belize and Border Countries.* [www document] <www.freedominbelize.com> (Accessed 11/8/09).

GBIF; Global Biodiversity Information Facility. (2009). [www document] <http://www.gbif.org/> (Accessed 18/05/09).

Görts-van-Rijn, A.R.A. & Judziewicz, E.J. (1990) *Flora of the Guianas. Serie A : Phanerogams. Fascicle 5. 187. Poaceae (Gramineae).* Koeltz Scientific Books.

Grassbase. (2009). The online world grass flora. [www document] <http://www.kew.org/data/grasses-db/> (Accessed 26/04/09).

Hatch, S.L.; Schuster, J.L. & Drawe, D.L. (1999). *Grasses of the Texas Gulf Prairies and Marshes.* Texas A & M University Press, USA.

Hickey, M. & King, C. (2000). *The Cambridge Illustrated Glossary of Botanical Terms.* Cambridge University Press, Cambridge.

INTKEY. (2009) DELTA-INTKEY website. [www document] <http://delta-intkey.com/> (Accessed 15/06/09).

JCU: James Cook University, Australia. (2009) NQ weeds by common name. [www document] <http://cms.jcu.edu.au/idc/groups/public/documents/presentation/jcudev_011731~5.3.jpg> (Accessed 28/07/09).

Lucidcentral. (2009) Lucid key building software website. [www document] <http://www.lucidcentral.org> (Accessed 15/06/09).

Mabberley, D.J. (2008) *Mabberleys Plant Book: A portable dictionary of plants, their classification and uses.* 3rd edn. Cambridge University Press, UK.

Olff, H. (1992) Effects of light and nutrient availability on dry-matter and N-allocation in 6 successional grassland species- Testing for resource ratio effects. *Oecologia* **89** (3):412-421.

Picasaweb (2009) Web images supplied by Google. [www document] <picasaweb.google.com/.../dTLnHz87XMu7vBlauGA7-Q> (Accessed 16/08/09).

Ratter, J.A.; Bridgewater, S. & Ribeiro, J.F. (2003) Analysis of the floristic composition of the Brazilian Cerrado vegetation III: Comparison of the woody vegetation of 376 areas. *Edinburgh Journal of Botany* **60** (1): 57-109.

Ravi, N. & Mohanan, N. (2002) *Common Tropical and Sub-tropical Sedges and Grasses, An Illustrated Account.* Science Publishers, Inc., Plymouth UK.

Stuart, N.; Barratt, T. & Place, C. (2006) Classifying neotropical savannahs of Belize using remote sensing and ground survey. *Journal of Biogeography* **33** (3): 476-490.

Swallen, J.R. (1955) Flora of Guatemala, Part II. Grasses of Guatemala. Contained in: *Fieldiana* **24** (2): 1-390.

Tropicos. (2009) Missouri Botanical Garden. [www document] <http://www.tropicos.org/> (Accessed 18/05/09).

Urban, L.; Bridgewater, S.G.M. & Harris, D.J. (2006) The Macal River: A floristic and phytosociological study of a threatened riverine vegetation community in Belize. *Edinburgh Journal of Botany* **63** (1): 95-118.

Wacker, L.; Baudois, O.; Eichenberger-Glinz, S. & Schmid, B. (2008) Environmental heterogeneity increases complementarity in experimental grassland communities. *Basic and Applied Ecology* **9** (5): 467-474.

Appendix 1: Instructions for Using the Lucid 'Grasses of Belize' Multi-Access Key

To install the Lucid3 Player

- Open the Lucid3 Player folder and then click on the 'install' file and follow the steps.

To open the Lucid 'Grasses of Belize' key

- Once the Lucid3 Player is installed select and open the file 'Grasses of Belize.lkc4'

Key Layout

The key is separated into 4 compartments:

- **Features Available** ie. The characters that can be chosen to score
- **Entities Remaining** ie. The taxa that are still to be keyed out. The taxa that have the character selected from the 'Features Available' box will show up in this box.
- **Features Chosen** ie. The characters that have already been chosen.
- **Entities Remaining** ie. The taxa that remain as candidates after character states have been selected.

Main Key Features

Feature	Icon in the menu bar to click on	Description
Show or Hide Feature & Entity Thumbnails		The thumbnails will either appear or shrink to small boxes.
'Best' Characters		-This will automatically take you to the character with best separating power for the taxa in question. To toggle through the different "Best" characters click on the icons with arrows.
Search for Character		Once selected enter the name of the character you are searching for. You can move through all the characters that include the word searched for until you find the correct one.
Expand/ Collapse Character List		The list of characters will either expand out to show all the characters and states

		that can be scored or collapse.
Restart Key		The key will begin again from scratch.
Differences		Shows a list of all the major differences between the taxa remaining to be keyed out

Viewing images

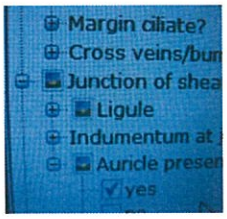
- To see an expanded view of a Feature or Entity thumbnail image click on the thumbnail and the larger version will be displayed.

- To see an expanded view of a character state thumbnail click on the small box at the bottom right of the thumbnail. →

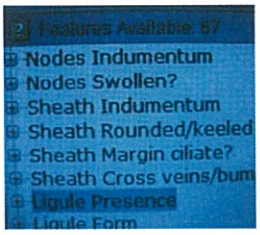
Trees & Lists

- The information in the boxes can be viewed in 2 ways.

- The 'Tree' option allows the user to see the characters and taxa in a hierarchical fashion. The plus box must be clicked to expand the tree branches to see more of the characters or the species contained within each genus.



- The 'List' option allows the viewer to see all the characters and taxa alongside each other. This option is more difficult to work through when keying out but is useful for seeing closely related characters or taxa alongside each other.



Appendix 2: List of the Collections and Species Determinations Made During Field Work.

NB. For a list of the specimens collected and identified from Deep River Forest Reserve and the boundary with Bladen Nature Reserve see Table 16, Chapter 3.

Collector number	GENUS	Species epiphet	Location
SPS8	*Schizachyrium*	*microstachyum*	Belmopan
SPS9	*Bothriochloa*	*pertusa*	Belmopan
SPS53	*Dichanthium*	*annulatum*	Golden Stream Village
SPS54	*Sporobolus*	*jacquemontii*	
SPS55	*Andropogon*	*glomeratus*	
SPS56	*Paspalum*	*blodgettii*	
SPS57	*Paspalum*	*virgatum*	
SPS58	*Leptochloa*	*virgata*	
SPS59	*Axonopus*	*compressus*	
SPS60	*Sporobolus*	*jacquemontii*	
SPS61	*Chloris*	*inflata*	
SPS62	*Ichnanthus*	*tenuis*	
SPS63	*Ichnanthus*	*tenuis*	
SPS64	*Panicum*	*polygonatum*	
SPS65	*Sorghum*	*halepense*	
SPS66	*Rottboellia*	*cochinchinensis*	
SPS67	*Echinochloa*	*colona*	
SPS68	*Paspalum*	*fimbriatum*	
SPS69	*Urochloa*	*fasciculata*	
SPS70	*Heteropogon*	*contortus*	Mountain Pine Ridge
SPS71	*Axonopus*		
SPS72	*Homolepis*	*aturensis*	
SPS73	*Aristida*	*setifolia*	
SPS74	*Panicum*	*haenkeanum*	
SPS75	*Heteropogon*	*contortus*	
SPS76	*Axonopus*	*fissifolius*	
SPS77	*Panicum/ Dichanthelium*	*P.haenkeanum/ D.portoricense*	
SPS78	*Aristida*	*recurvata*	
SPS79	*Paspalum*	*orbiculatum???*	
SPS80	*Paspalum*	*pilosum*	
SPS82	*Thrasya*	*campylostachya*	
SPS83	*Eragrostis*	*simpliciflora?*	

SPS84	*Dichanthelium*	*strigosum var. strigosum*	Mountain Pine Ridge
SPS85	*Paspalum*	*pectinatum*	
SPS86	*Axonopus*	*capillaris*	
SPS87	*Dichanthelium*	*aciculare var. ramosum*	
SPS88	*Sporobolus*	*jacquemontii*	
SPS89	*Panicum*	*polygonatum*	
SPS90	*Paspalum*	*new spp?*	
SPS91	*Paspalum*	*new spp?*	
SPS92	*Aristada*	*setifolius?*	
SPS93	*Andropogon*	*selloanus?*	
SPS94	*Aristida*	*appressa*	
SPS95	*Paspalum*	*virgatum?*	
SPS96	*Cynodon*	*dactylon*	San Ignacio
SPS97	*Panicum*	*maximum*	
SPS98	*Olyra*	*latifolia*	Belize Botanic Garden
SPS99	*Acroceras*	*zizanoides*	
SPS100	*Setaria*	*parviflora*	
SPS101	*Paspalum*	*paniculatum*	
SPS102	*Paspalum*	*plicatulum*	