Testing highly variable chloroplast and nuclear markers in *Caesalpinia s.l.*

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Caesalpinia pulcherrima, G.D. Carr
http://www.botany.hawaii.edu/FACULTY/CARR/images/poi_pul_cu.jpg

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Kew — PLANTS PEOPLE POSSIBILITIES

Caesalpinia gilliesii

Source : M.-A. Archambault

Caesalpinia decapetala

Source: Forest & Kim Starr

http://www.hear.org/starr/images/full/starr-011205-0121.jpg

Caesalpinia echinata

Source: G. P. Lewis

http://www.arkive.org/pau-brasil/caesalpinia-echinata/image-G2285.html

Caesalpinia calycina

Source: G. P. Lewis
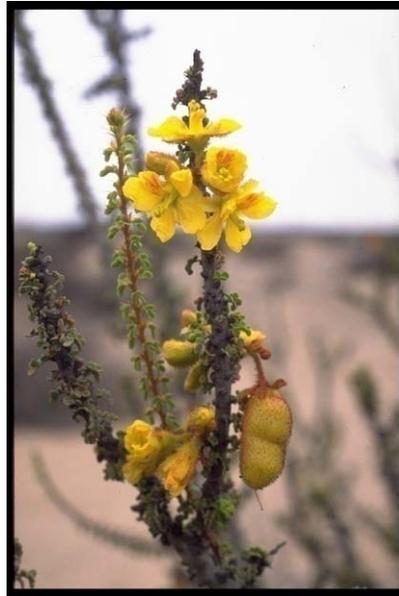
Balsamocarpon brevifolium

Source: G. P. Lewis

Caesalpinia meladenia

Source: Donavan Bailey
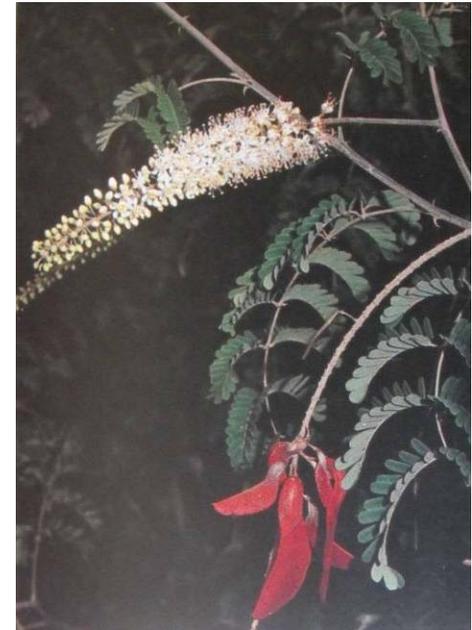
Pterolobium stellatum

Source: G. P. Lewis

Taxonomic classification of Caesalpinia s.l.

(Lewis 2005)

Proposal to reinstate 8 genera in Caesalpinia sensu lato

• **Does molecular evidence to support this classification?**

•**What are the generic delimitations?**

•**Relationships among genera?**

Genus	Nb species
Balsamocarpon	1
Cordeauxia	1
Moullava	1
Stahlia	1
Stuhlmannia	1
Zuccaginia	1
Stenodrepanum	1
Cenostigma	2
Haemotaxylon	3
Hoffmannseggia	24
Pomaria	16
Pterolobium	11
Caesalpinia (Coulteria)	10
Caesalpinia (Erythrostemon)	~ 13
Caesalpinia (Guilandina)	7 – 18
Caesalpinia (Libidibia)	8
Caesalpinia (Mezoneuron)	26
Caesalpinia (Poincianella)	~ 36
Caesalpinia (Tara)	3
Caesalpinia sensus stricto	~ 25

Why past studies have failed to determine generic delimitations:

27 generic names associated with *Caesalpinia* s.l.

Lack of synapomorphic/diagnostic characters in morphology (Lewis and Schrire, 1995).

Not enough variation in selected genetic markers

(Simpson and Miao, 1997, CpDNA restriction sites; Simpson *et al*. 2003, trnL-F)

Not enough species to represent Caesalpinia s.l.

(Simpson et al., 2004, 2005, Hoffmannseggia ; Simpson et al., 2006, Pomaria)

(Sotuyo et al., 2007, Caesalpinia hintonii complex; Bruneau et al., 2008)

Taxonomic classification of Caesalpinia s.l.

(Lewis 2005)

Research Objectives

1. Adequate taxonomic sampling

2. Find variable genetic markers

3. Biogeographic analysis to explore evolution of SDTF

Genus	Nb species	Nb species in lab
Balsamocarpon	1	1
Cordeauxia	1	1
Moullava	1	1
Stahlia	1	1
Stuhlmannia	1	1
Zuccaginia	1	1
Stenodrepanum	1	1
Cenostigma	2	2
Haemotaxylon	3	2
Hoffmannseggia	24	5
Pomaria	16	2
Pterolobium	11	1
Caesalpinia (Coulteria)	**10**	6
Caesalpinia (Erythrostemon)	**~ 13**	3
Caesalpinia (Guilandina)	**7 – 18**	5
Caesalpinia (Libidibia)	**8**	5
Caesalpinia (Mezoneuron)	**26**	11
Caesalpinia (Poincianella)	**~ 36**	33
Caesalpinia (Tara)	**3**	3
Caesalpinia sensus stricto	**~ 25**	8

Pilot test of highly variable markers

Chloroplast markers

Marker	Source
1. *psbA-trnH*	(Sotuyo et al., 2007; Simpson et al., 2004)
2. *rps16*	(Haston et al., 2005)
3. *rpL16*	(Marazzi et al., 2006)
4. *trnD^{GUC}-trnT^{GGU}*	(Simon et al., 2009; Kursar et al., 2009; Shaw et al., 2005)
5. *trnS^{GCU}-trnG^{UUC}*	(Shaw et al., 2007)
6. *rpoB-trnC ^{GCA}*	(Shaw et al., 2005)
7. *trnC^{GCA}-ycf6*	(Demesure et al. 1995; Shaw et al., 2005)
8. *ycf6-psbM*	
9. *NdhF-rpL32*	(Shaw et al., 2007)
10. *rpL32-trnL^{UAG}*	(Shaw et al., 2007)
11. *matK*	(Bruneau et al., 2008)

Low-Copy Nuclear markers *

Marker	Source
1. LEAFY/ Floricaula	(Archambault and Bruneau, 2004)
2. CNGC4	(Choi et al., 2006)
3. ARG10	(Choi et al., 2006)
4. AIGP	(Choi et al., 2006)
5. UDPDG	(Choi et al., 2006)
6. tRALS	(Choi et al., 2006)
7. MMKI	(Choi et al., 2006)
8. SqdI	(Li et al., 2008)

* At least one sample was cloned for each marker.

Selected markers for *Caesalpinia s.l.*

1. ***rps16*** (Peltophorum group, Haston et al., 2005)

2. ***trnD^{GUC}-trnT^{GGU}*** (Simon et al., 2009; Kursar et al., 2009; Shaw et al., 2005)

3. ***ycf6-psbM*** (Demesure et al. 1995; Shaw et al., 2005)

4. ***trnL*: Bruneau lab + Simpson et al., 2003**

5. ***ITS*: Bruneau lab + Pomaria + Hoffmannseggia**

(Simpson et al., 2005; 2006)

- **Parsimony analysis for each marker**

- **Parsimony for combined matrix of five markers**

Parsimony results

- Same phylogenetic groups in the strict consensus trees in the independent and combined analysis

- Relationships amongst these groups is unclear : weak backbone of the phylogeny

	trnL	ITS	rps16	trnD-trnT	ycf6-psbM
Nb Taxon	122	104	103	90	48
Nb Characters	605	725	953	1663	1513
Parsimony-Informative Caracters	119 (17,6%)	471 (55,6 %)	160 (16,8%)	249 (15,0%)	191 (12,6%)
Nb Trees	+10,000	664	+10,000	+10,000	8
Length Trees	343	3227	436	732	469
Consistency Index	0.7289	0.3042	0.7385	0.7077	0.7655
Retention Index	0.9018	0.6958	0.8874	0.8481	0.8634
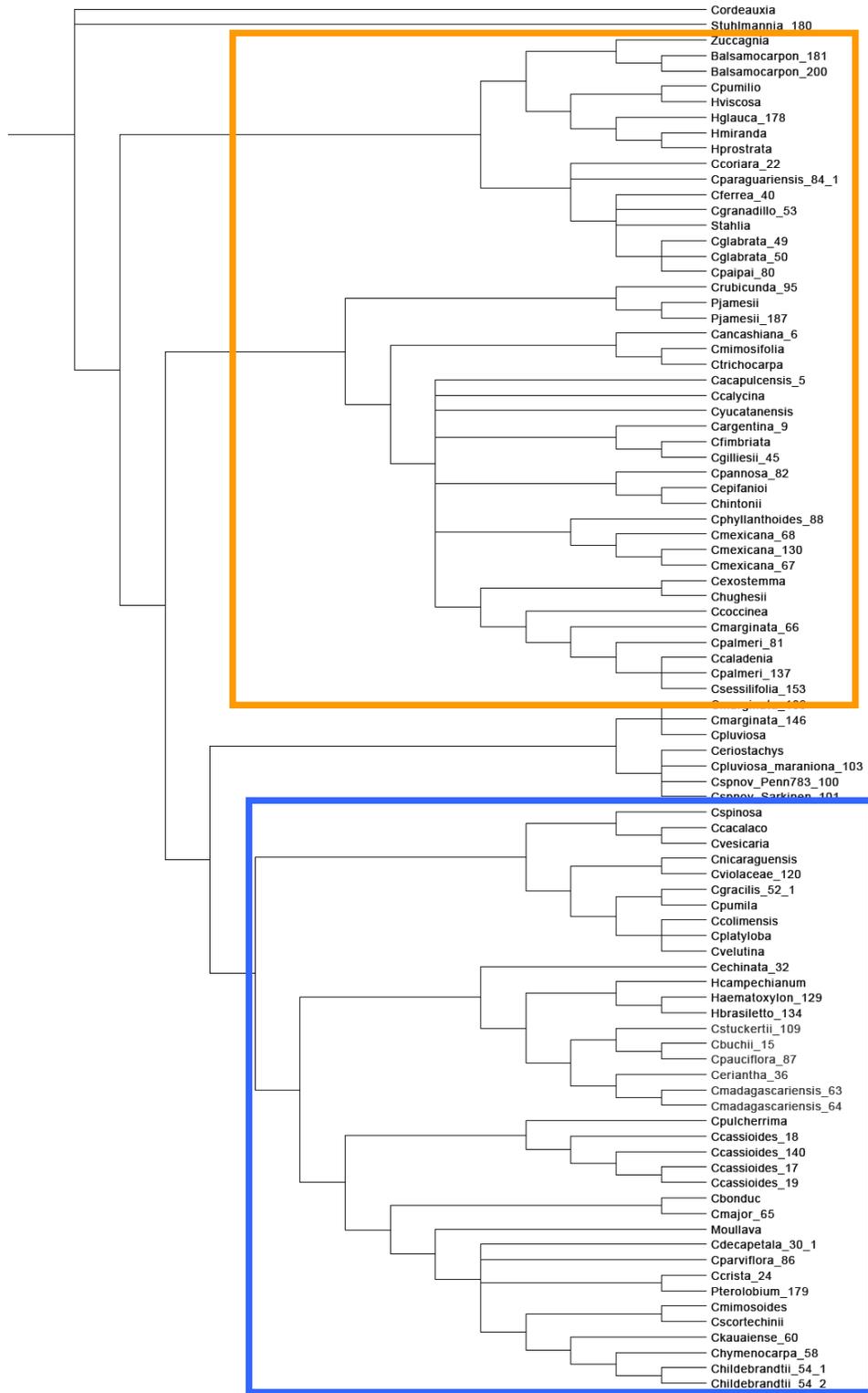
Parsimony Analysis of Combined Matrix

Outgroup: *Cordeauxia*

Strict consensus of 10,000 trees

Caesalpinia group 1 Neotropics

Balsamocarpon	*Zuccagnia*
Hoffmannseggia	*Libidibia*
Stahlia	*Poincianella*
Erythrostemon	*Pomaria*

90 taxa (~75 species)

5369 characters

Pluviosa clade

Caesalpinia group 2 Old tropics + Neotropics

Fast Bootstrap:
5000 replicates
no branch swapping.

Tara	*Coulteria*
Haematoxylon	*Caesalpinia ss*
Moullava	*Guilandina*
Mezoneuron	*Pterolobium*

Caesalpinia group 1
**Parsimony Analysis
Strict consensus of 10,000 trees**

Erythrostemon calycina
G. P. Lewis

Ceriostachys
Cpluviosa_maraniona_103
Cspnov_Penn783_100
Cspnov_Sarkinen_101
Cmarginata_139
Cmarginata_146
Cpluviosa
72
77

Poincianella B, Pluviosa clade

Central america + Brazilian species

Pjamesii_187
Pjamesii
Crubicunda_95
100
100

Pomaria, Neotropics + South Africa

Ctrichocarpa
Cmimosifolia
Cancashiana_6
100
100

Trichocarpa clade, South America:
Andes

57

Cyucatanensis
Cphyllanthoides_88
Cmexicana_68
Cmexicana_67
Cmexicana_130
Cpannosa_82
Chintonii
Cepifanioi
Ccalycina
Chughesii
Cexostemma
Ccoccinea
Cmarginata_66
Cpalmeri_81
Csessilifolia_153
Cpalmeri_137
Ccaladenia
98
76
66
67
92
75
73
77
68
83
72
89

Poincianella A

Mexico + Central America

Caesalpinia
Pomaria

Cgilliesii_45
Cfimbriata
Cargentina_9
88
99

Erythrostemon, South America

Cacapulcensis_5

Cparaguariensis_84_1
Stahlia
Cgranadillo_53
Cpaipai_80
Cglabrata_50
Cglabrata_49
Cferrea_40
Ccoriara_22
76
59
62

Libi

Hprostrata
Hmiranda
Hglauca_178
Hviscosa
Cpumilio
100
100
67

Hof

Zuccagnia
Balsamocarpon_200
Balsamocarpon_181
79
99

B

Zuccagnia

Poincianella pannosa
G. P. Lewis

Cordeauxia
Stuhlmannia_180

G. P. Lewis

Caesalpinia group 2
Parsimony Analysis
Strict consensus of 10,000 trees

Caesalpinia pulcherrima

Moullava spicata
G.P. Lewis

Tara spinosa
G.P. Lewis

Caesalpinia madagascariensis
G.P. Lewis

Pterolobium stellatum
Source: G. P. Lewis

67 — Cbonduc / Cmajor_65 — *Guilandina* (Pantrop

92 — Ccrista_24 / Pterolobium_179 → *Pterolobium,*

Cdecapetala_30_1

99 — Childebrandtii_54_1 / Childebrandtii_54_2
51 — Chymenocarpa_58 / Ckauaiense_60
75 — Cmimosoides / Cscortechinii

Mezoneuron, Asia

53

Cparviflora_86

Moullava → *Moullava,* India

86 — 82 — Ccassioides_140 / Ccassioides_17 / Ccassioides_19 / Ccassioides_18
99 — Cpulcherrima
95

Caesalpinia s.s., S,

96 — Cbuchii_15 / Cpauciflora_87
51 — Cstuckertii_109
82 — Ceriantha_36
100 — Cmadagascariensis_63 / Cmadagascariensis_64
99

Caesalpinia s.s.

100 — 100 — Haematoxylon_129 / Hbrasiletto_134 / Hcampechianum

Haematox

Cechinata_32

97 — 98 — Ccacalaco / Cvesicaria / Cspinosa

Tara

61 — Ccolimensis / Cplatyloba / Cvelutina
52
99 — Cgracilis_52_1 / Cpumila
99 — Cnicaraguensis / Cviolaceae_120
81

Coulteri

Caesalpinia kavaiensis
Fabaceae - Caesalpinioideae
© Tim Motley

Mezoneuron kavaiense
G. D. Carr
http://www.botany.hawaii.edu/FACULTY/CARR/images/cae_kav.jpg

Some of the classification of Caesalpinia s.l. by Lewis (2005) seems to be supported by our results, but more work is needed!

Developing and scoring a matrix of morphological characters : defining diagnostic characters

- Collaboration with G. P. Lewis

- Main challenge: Poincianella-Erythrostemon (+ Pomaria) group

Biogeographical analyses of Seasonally Dry Tropical Forests

Developing *Poincianella-Erythrostemon* group as a biogeographic model to investigate speciation of SDTF:

- Strong geographic structuring of the phylogeny of Caesalpinia s.l.

- Molecular dating analysis with fossil data

    - Mezoneuron (45 mya)

    - Caesalpinia sensu stricto (45 mya

Seasonally Dry Tropical Forests

- The succulent biome: 5-6 months <100mm of rain, continuous canopy, more fertile soils, low levels of disturbance.

- >50% SDTF in Neotropics: Cactaceae, Bigognaceae, Leguminosae;

- 97% of remaining SDTF under threat (Miles et al. 2006);

- Disjunct SDTF Arc:
    - High level of beta diversity; endemics.
    - *C. celendinensis, H. aphylla, C. pluviosa var. maraniona*
    - Vicariance or dispersal?

Savanna
Chaco
Seasonally dry tropical forest
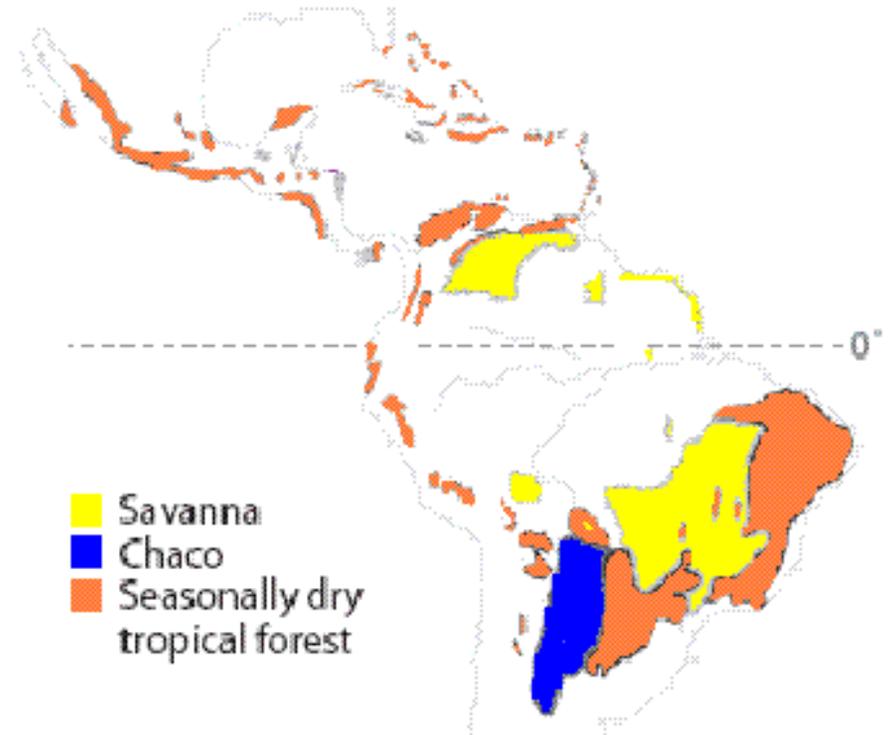
Modified from Pennington et al., 2009

Acknowledgements

I would like to thank QCBS, NSERC, FQRNT, ASPT and IRBV for support and funding of this work.