Leucaena: species diversity & genetic resources

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1983 – 1997
Fieldwork in Central America, northern South America, Mexico & the U.S.A.
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1998

2001-2003
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2004 onwards
Inputs to a series of projects on phylogenetics and genomics of Leucaena led by Donovan Bailey, New Mexico State University, U.S.A.
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Monograph of Leucaena
(Leguminosae-Mimosoideae)
Colin Hughes

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Figure 33 Map of south central Mexico showing the present day distribution of L. esculenta
- Taxonomy
- Species characteristics: tree size & form, ecogeography, psyllid resistance, phenology, wood quality, leaf quality, growth rates, weediness
- Ethnobotany & indigenous domestication as a food plant
- Hybrids
- Germplasm collections
- Seed management
- Conservation
- Domestication
- Identification
- Species accounts
Leucaena Online Data Resources

• *Images, distribution maps and an online key* constructed by Patrick Alexander for the identification of Leucaena species are available at: http://polyploid.net/leucaena/


• *Leucaena Genetic Resources Handbook* – a .pdf [in English (TFP37) or in Spanish (TFP37S)] can be downloaded from the Bodleian Library in Oxford: http://www.bodley.ox.ac.uk/users/millsr/isbes/ODLF/TFP37.pdf

• *An online taxonomic and specimen database for Leucaena* is available, including data on more than 2800 specimens in 26 herbaria. Detailed field notes, common names, phenology and duplicate records are included, and the majority of specimens (2393) are georeferenced, at: http://herbaria.plants.ox.ac.uk/bol/leucaena
Species Limits

• Potential problems in the circumscription of some species, particularly for *L. lanceolata*, motivated re-assessments of species limits

• 424 accessions representing two or more populations of each diploid species
• 3 selective AFLP primer combinations
• 1315 loci scored for diploids
• Principle coordinates (MVSP) and STRUCTURE vers. 2.3.1

Govindarajulu et al. (2011)
L. collinsii

L. zacapana

Govindarajulu et al. (2011)
Two species added in 2011:

**Leucaena cruziana**
- Newly recognized lineage separate from *L. lanceolata*
- One of the diploid progenitors of tetraploid *L. leucocephala*

**Leucaena zacapana**
- Sister to *L. collinsii*, but deeply divergent and geographically isolated
- Upranked from subspecies
24 species
19 diploid species

collinsii
cruziana
diversifolia
esculenta
zacapana
lanceolata
retusa
confertiflora
cuspidata
trichodes
greggii
trichandra
salvadorensis
pallida
shannonii
leucocephala
involucrata
lempirana
macrophylla
magnifica
matudae
multicapitula
pueblana
pulverulenta

5 tetraploid species

19 diploid species
Distribution of the genus Leucaena
Leucaena leucocephala

Tetraploid – L. cruziana x L. pulverulenta

Fast-growing, easily managed

Psyllid susceptible

Excellent forage quality – the alfalfa of the tropics

One of the most common trees in the tropics

Invasive & weedy
Leucaena diversifolia

Tetraploid – L. pulverulenta x L. trichandra

Out-yields L. leucocephala under mid-elevation, cool but frost-free tropical highland conditions

Moderately psyllid resistant

Lower palatability and digestibility and higher condensed tannin levels than L. leucocephala

Spontaneous and artificial hybrids with L. leucocephala – L. x spontanea and KX3
Leucaena pallida

Tetraploid – L. pueblana x L. trichandra

Branchy habit, fast growing & high yielding

Cool tolerance

Excellent psyllid resistance

Lower edible fraction, higher condensed tannins and lower digestibility than L. leucocephala

Hybrids with L. leucocephala – KX2
Leucaena involucrata

Tetraploid – likely an outlying species derived from tetraploid L. pallida, with which it shares the L. pueblana and L. trichandra diploid parentage

Similar in many ways to L. pallida, but poorly known

Known from just a handful of collections from Sonora in NW Mexico.

Potential and characteristics largely unknown
Leucaena confertiflora

Tetraploid – L. trichandra x L. cuspidata

Small multi-stemmed tree; probably slow growing.
Cultivated and incipiently domesticated in S-C Mexico

High elevation – 2500 m – cold tolerant

Highly psyllid resistant

Leaves: low digestibility and high condensed tannin

Spontaneous hybrids with L. leucocephala
Leucaena pulverulenta

- One of the better known species; fast growing
- Moderate cold and limited frost tolerance, 19-29°N
- Moderately to highly susceptible to psyllids
- Leaves: low mimosine, but lower in vitro digestibility, crude protein & and higher condensed tannin than L. leucocephala
- One of the diploid progenitors of L. leucocephala.
- L. pulverulenta x L. leucocephala triploids
Leucaena trichandra

- Extremely variable: very wide geographic range. Seed source critically important.

- Sources from SE Guatemala especially promising

- Variable in morphology, leaves, growth rates, psyllid resistance, condensed tannin

- Tolerates nutrient-poor acidic soils

- Triploid hybrids with L. leucocephala
Leucaena esculenta

- Large tree; fast growing; high yield
- Moderately drought tolerant – 7 month dry season
- High psyllid resistance
- Leaves: low edible fraction; low in vitro dry matter digestibility; high condensed tannin
- Frequent sterile triploid spontaneous hybrids with *L. leucocephala* = KX4
Leucaena cruziana & L. lanceolata

- Truly tropical – coastal – mainly < 400m elevation
- Low psyllid resistance
- Leaves: high in vitro digestibility, low condensed tannin content – forage quality similar to L. leucocephala
- L. cruziana = diploid progenitor of tetraploid L. leucocephala
Leucaena collinsii & L. zacapana

- Notable for dense durable wood & high wood biomass production
- Drought tolerant – 500-700 mm rainfall; 7 month dry season
- Highly psyllid resistant
- Leaves: high digestibility and low to zero tannin content
Leucaena retusa
Leucaena greggii

- Slow growing
- The two most northerly species 25-30°N
- Frost tolerant
- Psyllid resistant
- Leaves – low digestibility and high condensed tannin
Leucaena cuspidata

- Poorly known and unusual species
- Rarely cultivated so far
- Growth potential unknown, but probably slow growing
- Multi-stemmed from base
- Cold tolerant – 1400-2400 m elevation
- Leaves – little data – but probably low digestibility and high condensed tannins
Leucaena matudae & L. pueblana

- Poorly known
- Rarely cultivated, but probably slow growing
- Drought tolerance – 500 – 800 mm mean annual rainfall, 7-8 month dry season
- Highly psyllid resistant
- Leaves – low crude protein content & high condensed tannin levels
L. multicapitula

- Poorly known

- The largest Leucaena forming a large tree to 25m height. Fast growing

- Tropical lowland forest, including rain forests with rainfall up to 2500 mm

- Leaves: highly susceptible to psyllid; high in vitro digestibility, low condensed tannin; high forage quality
Leucaena salvadorensis

- Overlooked species until recently

- Highly esteemed species for wood production – fast growing, dense wood & high wood biomass producer

- Moderately susceptible to psyllid

- Forage quality poorly known, but probably high in vitro digestibility & low condensed tannin, but lower palatability than leucocephala
Leucaena shannonii

- Limited potential
- Slow growing
- Moderately susceptible to psyllids
- Good forage quality – very high crude protein content, high in vitro digestibility, low condensed tannin content
Leucaena magnifica

• Species discovered in 1984; only known from a few populations in SE Guatemala, <400km² natural range – critically endangered species

• Large tree, fast growing

• Moderately psyllid susceptible

• Leaves: high in vitro digestibility, very low condensed tannin
Leucaena lempirana

- Discovered in 1990 and first described in 1997
- Tree to 15 m ht
- Poorly known and little tested in trials
- Highly susceptible to psyllid
- Forage potential unknown
Leucaena trichodes

- Only species native to South America
- Poorly known and rarely cultivated; potential little investigated
- Leaves: high in vitro digestibility, very low (almost zero) condensed tannin
Leucaena macrophylla

- Very large leaflets (3-7 cm long)
- Two subspecies – the coastal subspecies istmensis very fast growing in trials
- Moderately susceptible to psyllids
- Leaves: little used for forage so far. High in vitro digestibility, low condensed tannins
Triploid Hybrids

**L. pulverulenta x L. leucocephala**
- First spontaneous hybrid noticed in the genus in west Java, where 2 parents cultivated since 1900
- First artificial hybrid to be used commercially – propagated by grafting as a shade tree over tea plantations in Indonesia.
- Fast-growing, outperforms L. leucocephala, but highly susceptible to psyllids
- Completely sterile or weakly fertile

**L. trichandra x L. leucocephala**
- Spontaneous hybrids in Indonesia
- Artificially recreated in Hawaii
- Largely sterile

**L. esculenta x L. leucocephala**
- Very frequent and widespread spontaneous hybrid in S-C Mexico – named Leucaena xmixtec, also in Colombia & Senegal
- Completely sterile
- Artificially generated in Hawaii
- Fast growing
Leucaena x mixtec

Sterile triploid hybrids

= L. Leucocephala (tetraploid) x L. esculenta (diploid)

= KX4
Guaje macho - Leucaena x mixtec – sterile triploid hybrids

> 50 individual trees
Puebla, Morelos, Oaxaca, Chiapas, Guerrero

Independent F1 hybrids
Leucaena x mixtec
= L. Leucocephala (tetraploid) x
L. esculenta (diploid)

Triploid leaf formula
$3\ln F_1 = 2\ln P_1 + \ln P_2$

Spontaneous Hybridization

When species are brought together in artificial sympatry – spontaneous hybrids are highly likely to occur. These can be cryptic and hard to identify.

Likely that this accounts for the origins of some of the tetraploids, including L. leucocephala

We have documented a significant number of such spontaneous hybrids:
- L. xmixtec (KX4) widespread in Mexico; also documented in Senegal, west Africa
- L. xspontanea – L. leucocephala x L. diversifolia – common in Veracruz, Mexico and individuals also found in northern Guatemala
- Probable L. leucocephala x L. confertiflora tetraploid hybrid in Puebla, Mexico
- L. leucocephala x L. pulverulenta in Indonesia
- L. leucocephala x L. trichandra

What can happen, probably will happen, given time.

For example, with widespread deployment of triploids one should expect at some point a hexaploid to appear
Conclusions

Tremendous diversity in the genus

Wide range of environmental tolerances – cold, drought etc –

Species bioclimatic niche modelling using comprehensive species occurrence data – predict where species will grow

Very wide range of forage quality traits, growth rates, psyllid tolerances

Hard to rank diploids in a simplistic way – lack of adequate data on forage quality for many species. Several species remain very poorly known.

L. pulverulenta – diploid progenitor of L. leucocephala
L. trichandra – critical importance of seed source – provenance

The history of Leucaena breeding is a history of (i) chasing a moving target as new challenges come along – first mimosine, then psyllid tolerance, now sterility; (ii) over-reliance on a very narrow genetic base, e.g. single self-fertile lines of L. leucocephala.