Seven decades of leucaena R&D&E in Australia: What we have achieved

1. Brief history of leucaena
2. Leucaena for forage in Australia
3. R&D&E from 1960 onwards
4. Environmental issues
5. Future research priorities

Assoc.Prof. Max Shelton

The University of Queensland
1. Brief history of *Leucaena*

- **Origins of *Leucaena***
  - Genus found from southern US through Mexico to Central America
  - Food for several thousand years
  - Transported to SEA (Philippines) by Spanish colonists (1600s?)
  - Arrived in Australia late 1800s from PNG
Multipurpose uses around world (miracle tree)

- Furniture
- Forage
- Fuelwood
- Food
Leucaena for paper pulp in India (~100k ha)

Leucaena wood biomass for power generation
2. Leucaena for forage in Australia

- First varieties released in 60s - CSIRO
- First commercial plantings early 80s
- Large scale plantings began in 90s
- Now have >200,000 ha supporting >150,000 cattle
- Approximately 10-20 tonnes of seed sold every year = enough for 4000 - 8000 ha/yr
- Predict 300-500,000 ha in next 5-10 years
Where grown in Queensland

More than 12 M ha of land suitable for leucaena

Central Queensland grazier has 6000ha of leucaena
Grazed dryland leucaena in Central Queensland in winter
Central Queensland grazier has 240ha under pivot irrigation
Central Queensland grazier backgrounding Wagyu cattle
How we establish leucaena

- Almost all dryland, unfertilized
- Plant double rows, 6-8m centres
- Keep weed free until 1-2 m tall, then plant grass
- First graze when 2-4 m tall (6-12 months)
- Leucaena pasture expected to last 30-40 years
How leucaena is established in Queensland
(3 months)
How leucaena is established in Queensland
(6 months)
Leucaena being grazed appropriately
Leucaena in Colombia
About 71,000 scientific publications since 1950 (Google Scholar) covering:

- Germplasm collection and analysis, taxonomy.
- Multiple agroforestry uses e.g. alley cropping, timber.
- Agronomy and plant breeding.
- Animal production trials.
- Leucaena toxicity and discovery of *S. jonesii*.
- Environment & adoption.

![Graph showing publications every decade since 1950](image-url)
3. Leucaena R&D&E in Australia & University of Queensland (1990-2017)

- Max Shelton
- Scott Dalzell
- Ben Mullen
- Chris Lambrides
- Jim Brewbaker, Charles Sorensson (UH)
- Hayley Giles, Michael Halliday, Nahuel Pachas
- Lachlan Robertson, Andrew Hacker,
- Gerado Solis, Alex Radrizzani (LA)
- Greg Brown & Ross Gutteridge
- Juliette Warnick-Hayne, Dave Flatley
- Many other students, workers and helpers

Seven major R&D programs
3.1 *Leucaena* germplasm evaluation

- Long been botanical interest in the *Leucaena* genus (OFI, UH) – Monograph published by OFI
- Recognise 22 species including natural hybrids
- Arrival of leucaena psyllid in mid 1980s created impetus to study agronomy and nutritive value of entire genus

- *L. leucocephala* (4n)
- *L. pallida* (4n)
- *L. diversifolia* (4n)
- *L. trichandra* (2n)
- *L. collinsii* (2n)
- *L. esculenta* (2n)
- *L. macrophylla* (2n)
- *L. salvadorensis* (2n)

*L. retusa*
3.1 *Leucaena* germplasm evaluation

*Leucaena* spp. seed collected from multiple collection trips by US, UK and Australia to Mexico and Central America from ~1950, held in 5 international seedbanks

- SARDI, South Australia
- CIAT, Colombia
- ILRI, Ethiopia
- UH, Hawaii
- OFI, UK
UQ Genotype x environment trials (1995-2000) (Ben Mullen)

- Multi-environment trials (25 representatives from 116 accessions, representing 14 spp. and 2 interspecific hybrids
- Planted at 18 sites, 7 countries, representing wet/dry, low/high psyllids, hot/cool, and acid soil environments
- Data analysed by ANOVA and for Genotype x Environment interactions
Mean DM yields in 8 environments (Mullen 2001)

Environment groups:
- IRRI
- Very hot & wet & low psyllids
- Unitech
- Hot/wet & low psyllids
- Sungei Putih
- Hot/mod rain & low psyllids
- Highland tropical & low psyllids
- Dry or cold & high psyllids
- Acid infertile or cold or dry & high psyllids

Environment groups:
- Gr 1 (1)
- Gr 2 (1)
- Gr 3 (1)
- Gr 4 (8)
- Gr 5 (9)
- Gr 6 (2)
- Gr 7 (17)
- Gr 8 (22)
Mean DM yields of 7 accession groups (Mullen 2001)

Hybrid was high yielding
3.2 *Leucaena* spp. Forage quality
Tannins and digestibility of (Scott Dalzell)

- **Most tree legumes**, including *Leucaena* spp., **contain tannins**
- **Good**: by-pass protein (*L. leucocephala*)
- **Bad**: reduce overall digestibility of protein (*Calliandra, Acacia, Flemingia, Prosopis, L. pallida*)

![Graph showing interspecific variation in CT](image)
Protein binding (astringency) of CT varies with species, and reduces digestibility of most *Leucaena* spp. (McNeill et al. 1998)
3.2 Leucaena spp. Forage quality
Tannins and digestibility of (Scott Dalzell)

$5 = 25\% CP/5\% CT$
High CT spp. (*L. pallida*) are poorer in LWG (Galgal, 2000)

Animal productivity low in high CT *Leucaena* spp.
3.3 Varietal release and plant breeding

Leucaena cultivars

- Peru and Cunningham (1960s)
- Tarramba (1996)
- Wondergraze (2011)
- Redlands (psyllid resistant) (2015)

The leucaena psyllid
Heteropsylla cubana

Natural predators

Psyllid damage
Breeding program based on interspecific hybrid between *L. leucocephala* and *L. pallida*
Leucaena preference trial – North Queensland
(Compared preference of cattle for Redlands + 3 breeding lines with Cunningham & WonderGraze X 8 replications)
Exclusive rights to grow and market cv. Redlands leucaena

cv. Redlands June 2017
3.4 Plant nutrition – Phosphorus and sulphur
**P and S play key role of in nitrogen fixation**

- **P & S are deficient**
- **S is OK, P deficient**
- **P & S are OK**
- **Adequate**
- **Marginal**
- **Deficient**

Nitrorgen concentration in YFEL (%DM)

(PxS index)

P and S status of leucaena leaves
Leucaena fertilized with S
3.5 Leucaena plant density and legume-grass balance

Experiment was conducted to test effect of leucaena density and row spacing on relative proportion of leucaena and grass.
Tree densities and grass competition studied using a Nelder fan design

Pachas, ANA, Shelton HM, Lambrides CJ, Dalzell, SA, Murtagh GJ.
80,000 trees/ha
8,616 trees/ha
928 trees/ha

Rhodes grass
100 pl/ha
Percentage of grass/legume edibility

- Mexico: Up to 8000 trees/ha
- Colombia: 1500 trees/ha
- Indonesia: 1500 trees/ha

Log density (trees/ha):
- Australia: 1500 trees/ha
- Mexico: Up to 8000 trees/ha

Percentage edible biomass (%): 0% to 100%
3.6 Animal studies in Australia

- Live weight gains
- Leucaena toxicity (new hypothesis presented)
3.6 Live weight gains

We know that leucaena has:

- High crude protein content (~20% CP in forage)
- High content of essential elements
- Very high palatability and digestibility
- Gives ‘by-pass’ protein
- Anthelmintic properties
Excellent weight gains due to high forage quality

<table>
<thead>
<tr>
<th>Forage system</th>
<th>Stocking rate (ha/steer)</th>
<th>Weight gain (kg/year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(700 mm rainfall)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buffel grass</td>
<td>2</td>
<td>170-190</td>
</tr>
<tr>
<td>Leucaena – buffel grass</td>
<td>1.2</td>
<td>250-300</td>
</tr>
</tbody>
</table>

**Weight gains (per ha)**
- Buffel grass: 85-95
- Leucaena – buffel grass: 210-250

High live weight gains (without supplement) x1.5
Excellent weight gains due to high forage quality

x1.5
X1.5
X2.5
Production data for 2013 from Taroom Rancher, Queensland

<table>
<thead>
<tr>
<th>Total cattle</th>
<th>Avg carcass Wt</th>
<th>Days owned</th>
<th>Wt gain/yr</th>
<th>Wt gain/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>2929</td>
<td>345kg</td>
<td>384 days</td>
<td>285kg</td>
<td>0.82kg</td>
</tr>
</tbody>
</table>
3.6 Animal studies - Leucaena toxicity

**Background Research into Toxicity**

- Leucaena contains mimosine (very toxic) which degrades to DHP (chronically toxic) in ruminants.

- Australian CSIRO scientist, Dr Raymond Jones (1970-2000), discovered a rumen bacterium that degraded mimosine and DHP — thought to be unique and novel to specific countries.

- Named *Synergistes jonesii*, it was discovered in Indonesia and Hawaii; later brought to Australia and distributed to ranchers.
From 2003-2016, UQ hand-collected 100s of rumen fluid and 1000s of urine samples from Australia, Indonesia, Thailand, Mexico
What we discovered was:

- **S. jonesii** indigenous across all geographical regions and ruminant spp tested, regardless of consumption of leucaena.
- **S. jonesii** present in low populations, too low to degrade high leucaena diets.
- In Thailand, Indonesia, Mexico, 1000s of urine samples from goats / cattle consuming **100%** leucaena had very high levels of 2,3-DHP in their urine.
- DHP not degraded by **S. jonesii**, but animals were healthy and gaining weight.
- DHP was being neutralized (conjugated) by compounds produced in liver and excreted in urine.

**Our new hypothesis:** Inoculation may not be necessary
3.7 Education training and adoption

Since 2004, UQ conducted:

- 30 courses in Aust. for >500 ranchers
3.7 Worked on adoption of Tarramba leucaena for cattle fattening in Indonesia (2011-2016)
4. Environment issues

**Negative issues**
- Weediness
- Leucaena spreads between rows when poorly managed
- Escapes to become a weed along roads and water courses
- New MLA project to produce a sterile leucaena

**Positive issues**
- Protects against drought
- Sustainable farming system
- Organic beef
- Erosion & water quality control
- Sequesters C and reduces methane production
- Renewable power generation
- Improved Animal welfare (dry season feed available, internal parasite control)
5. Continuing research priorities

- Toxicity – confirm conjugation of DHP occurs in other countries and other ruminant spp.
- Research anthelmintic value of leucaena for ruminants, non ruminants, humans
Thank you

Please feed me leucaena