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Jessie completed a Bachelor of Science in Chemistry, Forensic Biology and Toxicology at Murdoch University, followed by and Honours degree at UWA in 2009. For her PhD she moved into the relatively new field of sandalwood.

Sandalwood oil is one of the worlds’ most valuable essential oils. Unsustainable harvesting combined with other factors have led to an increased need to focus on plantation sandalwood for future supply.

W.A. sandalwood is native to the arid and semi arid regions of Western Australia.

Oil production is variable within this species both in concentration in heartwood and composition. Jessie’s research seeks to understand factors which control oil biosynthesis to aid future tree improvement, conservation and the potential for metabolic engineering of desirable oil constituents.
Improving plantation management and conservation of WA sandalwood (*Santalum spicatum*)

Jessie Moniodis

Supervisors: Prof. Julie Plummer, Prof. Emilio Ghisalberti, Dr Chris Jones, Dr Liz Barbour and Prof. Joerg Bohlmann
Acknowledgements

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Forest Products Commission
Sandalwood (*Santalum*)

Sandalwood Oil

Wood Products

Valuable and renewable resource
Santalum spicatum

- One of 15 Santalum species
- Native to Australia
- Once widespread
- Moving towards plantations
Heartwood Oil

Matures tree > 10 yrs

Heartwood

e.g. santalols

$\alpha$-

$\beta$-

Defense response?
**Santalum spicatum oil**

High chemical diversity within species

How????... Terpene synthases + P450s
Environment

- Grows in wheatbelt, Goldfields, Carnarvon, Shark Bay

Red sandy loams

Rocky/sandy soil
Hemi-Parasite

Sandalwood and Jam (Acacia acuminata)

Sandalwood with various hosts
Research Questions

WA sandalwood

Conservation

High variation in oil

Plantations

Genetic – diversity, terpene synthases, P450s, mutations in these genes

1. What is the genetic diversity and oil composition?
2. What genes encode for oil?
3. Are there mutations in these genes?

Environmental – host number and type, nutrients, soil, rainfall

1. Do environmental factors contribute to oil composition and yield?
Terpene Synthases (TPS)

angiosperm sesquiterpene synthases (C15)

monoterpene synthases (C10)

Chen et al. Plant J 66 (2011)
Method

Wood cDNA

Amplify gene + clone

E. coli

Transform + Express

Incubate w/substrates

Gene

Plasmid

GC-MS
Terpene synthase 1

<table>
<thead>
<tr>
<th>SspiSSy</th>
<th>Santalum spicatum Santalene Synthase</th>
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<tbody>
<tr>
<td>epi-β-santalene</td>
<td>α-bergamotene</td>
</tr>
<tr>
<td>α-santalene</td>
<td>β-santalene</td>
</tr>
<tr>
<td>P450? Enzyme</td>
<td></td>
</tr>
<tr>
<td>α-santalol</td>
<td>β-santalol</td>
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</tbody>
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- Gene phylogenetically similar to monoterpenes synthase (TPS-b)
- But high specificity for FPP ($K_m = 1.0 \mu M$)
Gene is phylogenetically similar to monoterpenes synthase (TPS-b)
Terpene synthase 3

Gene is phylogenetically similar to sesquiterpene synthase (TPS-a)
Evolutionary monoterpene (C10) synthases

TPS-b

SaMono, SspiBIS

SaPhel

SaSSy, SspiSSy

TPS-a

CitTPS

EucMTPS

MenSTPS, NicSTPS

CinMTPS

SalMTPS

AbiSTPS, PinSTPS

ArtSTPS

PogSTPS

TPS-d

RicDTPS

SspiSTPS

sesquiterpene (C15) synthases
Mutations in TPS genes

Single amino acid changes in terpene synthase genes can lead to different product profiles....

Are there mutation in the open reading frame of terpene synthases to account for different chemotypes?
Conclusions

✓ Terpene synthase genes characterised: major compounds
✓ Oil production highly conserved, survival importance
✓ TPS-b phylogenetic grouping with sesquiterpene function
✓ Possibilities for metabolic engineering: santalene synthase
✓ Approximately ¼ oil component described

[Graph showing farnesol]
- Other enzymes involved in oil biosynthesis – P450s
- Genetic diversity of natural populations and if there is a link to oil quality
- Environmental analysis: factors e.g. hosts, soil which may contribute to oil production
Future Research

Heartwood oil production genes highly conserved

How is oil produced and how is diversity controlled?

- Key to maximising quality plantation oil