Ngā Uri o Karaka:

A genetic study of the karaka/kōpi tree in Aotearoa/New Zealand

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Robin Amber Atherton

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Preface

Mihi

Ko Cymru te whenua
Ko Eryri te maunga
Ko Banwy te awa
Ko Vyrnwy te moana
Ko Robin Amber Atherton tōku ingoa

I was born in England to my father, whose father was a Yorkshireman, and whose mother was a Welshwoman from Anglesey, and my mother, whose parents were both from Yorkshire. I was raised partly in South Africa, but mostly in Cymru (Wales) in a small village called Y Foel nestled in the hills in the mid-central part of the principality. At primary school I learnt Welsh in full-immersion and delved into the Welsh world feet first, learning to recite Welsh poetry, sing Welsh songs and participating in cultural competitions, known as *eisteddfod*. My roots are firmly planted in the alluvial soils of the Banwy region, it is where I feel empowered and connected; it is my foundation, my home, my *tūrangawaewae*.

My love for *Papa-tū-a-nuku* (Mother Earth), the world around us, and my interest in languages and travel, brought me to Aotearoa to continue my studies. It felt comfortable here, like a second home, and I started to learn Te Reo Māori. Being the mother of a Māori child, my world and Te Ao Māori (the Māori world) become closer with each passing day.

My PhD research has taken me all over this beautiful land, collecting leaf samples and measuring karaka/kōpi tree trunks. I am fortunate to have seen hidden coves and inlets, cliffs and coastal banks, isolated hilltops and bluffs, that few others have. Through my study of the karaka tree, my roots have sunk deep into Papa-tū-a-nuku, and Aotearoa is now my home.

Mā te rongo, ka mōhio;

Mā te mōhio, ka mārama;

Mā te mārama, ka mātau;

Mā te mātau, ka ora.

Through resonance comes cognisance;

through cognisance comes understanding;

through understanding comes knowledge;

through knowledge comes life and well-being.

ABSTRACT

Polynesians translocated a number of plant species around the Pacific region. Many of these tropical crops were probably introduced to New Zealand, however, only a few survived owing to the cooler climate. Compensating for the loss of introduced crops, Māori cultivated endemic species they discovered in New Zealand. This project focuses on cultural and evolutionary aspects of the cultivation of one of these, karaka (*Corynocarpus laevigatus* Forst. & Forst.), which was cultivated for its highly nutritious kernel. Originally it is thought to have been restricted to the northern North Island. Its occurrence in the southern North Island, the South Island, Chatham and Kermadec Islands is strongly associated with Māori and Moriori archaeological sites and considered to have resulted from translocations as part of its cultivation. For this project, hypotheses were formulated based on existing written accounts of oral histories, published studies on karaka and informal observations and recollections. Oral histories exist regarding the origins of some translocated populations and have the potential to play an important role in tracing the history of karaka.

The relationships among the five *Corynocarpus* species were investigated by analyzing DNA sequences amplified using universal nuclear and chloroplast markers to test hypotheses of the inter- and intraspecific relationships of the genus. Nuclear markers suggest a closer relationship between *C. laevigatus* and *C. dissimilis* whereas the interpretation from chloroplast markers is less clear. This is indicated by the *rbcL* and *trnL-trnF* networks, which both show a reticulation suggesting support for both *C. laevigatus* and *C. similis* being more closely related to each other and *C. laevigatus* and *C. dissimilis* being more closely related. Nevertheless, in all cases, all markers suggest a close relationship between *C. laevigatus* and *Corynocarpus* species to the north of New Zealand (*C. dissimilis* in New Caledonia and *C. similis* in Vanuatu).

Using universal primers, intraspecific variation within karaka was found to be too low for studying translocation histories within New Zealand and extensive marker development was necessary. The first step in the development of chloroplast markers was characterisation of the chloroplast genome as a reference for different strategies in

molecular marker identification. A protocol was developed for the isolation of chloroplasts and the sequencing of the chloroplast genome using the Illumina Genome Analyser II. This protocol was also shown to be effective in the characterisation of chloroplast genomes in other elements of the New Zealand flora.

The sequence variability of the karaka chloroplast genome was investigated as a potential source for seed dispersal markers. A set of seven chloroplast molecular markers was developed and evaluated in terms of their potential for elucidating the history of karaka translocation during Māori settlement of New Zealand. Long-range polymerase chain reaction products were amplified from the chloroplast genome sequenced using Illumina Genome Analyser II, which enabled the identification of 48 putative chloroplast single nucleotide polymorphisms (SNPs). Sanger sequencing validated 16 of these detected SNPs. High resolution melting (HRM) was evaluated as an accurate, sensitive and fast PCR-based method to screen SNP variations in the chloroplast genome of karaka. Sufficient resolution in the data enabled an evaluation of the phylogeographic distribution of karaka to provide insight into the extent of human-mediated dispersal of the tree in New Zealand.

The results of the analysis of species-specific markers show the potential of the chloroplast genome to study recent events in plant history, and the use of HRM to assay several hundred accessions for a suite of chloroplast SNPs. They show an interesting relationship between Kermadec Island karaka and mainland karaka, and between Rekohu/Chatham Islands karaka and mainland karaka. To be able to pinpoint the location of the source for Rekohu/Chatham Islands karaka, more genetic work is required. However, these results are promising in their ability to trace the translocation of one of New Zealand's most important ethnobotanical species. By developing a more detailed picture of the genetic variation of karaka, this work has the potential to be the foundation for a deeper study into the translocation of the species. This has implications for further understanding the level of domestication in karaka, which at present cannot be ascertained.

Acknowledgments

Ehara taku toa, he taki tahi, he toa taki tini

My success should not be bestowed onto me alone,
as it was not individual success, but success of a collective

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