Copyright is owned by the Author of the thesis. Permission is given for a copy to be downloaded by an individual for the purpose of research and private study only. The thesis may not be reproduced elsewhere without the permission of the Author.

Birds in a tree: A journey through avian phylogeny, with particular emphasis on the birds of New Zealand

Gillian Claire Gibb

2010

A thesis presented in partial fulfilment of the requirements for the degree of Doctor of Philosophy in Genetics

Allan Wilson Centre for Molecular Ecology and Evolution
Institute of Molecular BioSciences
Te Kura Putaiao Koiora-a-Ngota
Massey University
Palmerston North
New Zealand

ABSTRACT

Two main themes to the avian research presented in this thesis are,
1. Deep resolution of birds generally, and
2. Investigation of specific aspects of the New Zealand avifauna.
More specifically, this thesis covers phylogeny, and predictions about palaeognaths, pigeons, pelecaniforms and passerines.

Significant progress is made in resolving the basal branches of Neoaves. This thesis examines whether the six-way basal Neoavian split of Cracraft (2001) is, in principle, resolvable. New mitochondrial genomes are added to improve taxon sampling, break up long branches, and allow testing of the prior assumptions of six Neoavian groups. This research shows the six-way split is resolvable, although more work is required for specific details. From a life-history perspective, it is interesting that the two bird-of-prey groups (falcons and buzzards) are very divergent, and may not be sister groups. Molecular dating supports major diversification of at least 12 Neoavian lineages in the Late Cretaceous. Additionally, novel avian mitochondrial gene orders are investigated and a hypothesis put forward suggesting gene conversion and stable intermediate forms allows an apparently rare event (gene rearrangement) to occur multiple times within Neoaves.

One of Cracraft's six groups, informally called the 'Conglomerati', is particularly difficult to resolve. The pigeons (Columbiformes) lie within the 'Conglomerati', and this chapter examines two aspects along the continuum of pigeon evolution. Firstly the large South Pacific fruit pigeon radiation is examined with mid-length mitochondrial sequences. This clade contains a third of all pigeon species, and has been very successful in island colonisation throughout South East Asia and the Pacific. Secondly, candidates for the closest relative of pigeons are tested using analysis of whole mitochondrial genomes. Highest support was found for the grouping of sandgrouse and pigeon, although they are clearly very divergent.

Also within the 'Conglomerati' is the traditional order Pelecaniformes, and their close allies the Ciconiiformes. These orders (the P&C) are part of an adaptive radiation of seabird water-carnivores, including loons, penguins, petrels and albatrosses. This group is separate from the large shorebird water-carnivore group; although both appear to have begun radiating abut 70 million years ago. The

tropicbird represents a separate, convergent life history and is not part of the Pelecaniformes, nor within the larger seabird water-carnivore group.

Resolution of the basal phylogeny of oscine passerines is important for interpreting the radiation of this group out of the Australasian region. Many endemic New Zealand oscine passerines belong to 'basal corvid' lineages, but have not previously been investigated with mitochondrial DNA. This chapter shows that many 'basal corvid' lineages are actually 'basal passerine' lineages, and there is a discrepancy between nuclear Rag-1 phylogenies (the most commonly used gene in passerine phylogenetics) and other phylogenies, including mitochondrial, that requires further investigation.

Taken as a whole, this thesis adds significantly to our understanding of the evolution of birds, and provides a foundation for future research, not only of phylogenetic relationships, but also of avian life history, long-term niche stability and macroevolution.

ACKNOWLEDGEMENTS

Firstly to David, thank you for being an amazing supervisor. Thank you for your incredible ability to read and return comments on just about anything overnight, for your wide-ranging knowledge, which I can only aspire to, and also for breakfast meetings!

To my co-supervisors, Matt, Trevor, and Lindell. Although widely dispersed when I started this project, you all ended up in Australia. I really appreciated visiting you all there, and meeting up at various conferences. In between times, thank you for always being at the end of an email.

To Trish, Abby, Matt and Kerryn, thank you for showing me how to do this funny thing called 'sequencing mitochondrial genomes' all those years ago. You guys taught me so much and I really appreciate it. Special thanks to Trish – you are the glue that holds this group together.

Thank you to Alan Cooper and Jeremy Austin for hosting me at the Australian Centre for Ancient DNA, and teaching me the principles of ancient DNA work. Thank you to Trevor, Jenny and Nic, for looking after me and taking me travelling around South Australia. With caves, fossils, kangaroos, wombats, and echidnas, you made my trip there something special.

To Steve, I've really enjoyed our 'constructive rants' on phylogeny, birds, New Zealand, and anything in between. Long may they continue!

Thank you to Joy and Susan for all your hard work behind the scenes and on the front line! You have always been able to 'get stuff done' at a moments notice, and I really appreciate that. And to Ann and Cynthia, thank you for being understanding when I put my head round the door for more milk!

On that note, cheers to all who came for a cup of coffee over the years. To Farside and Pleb labers, Boffin lounge and Goldfish bowl inhabitants. While too many to name here, you make the AWC a wonderful community to work in.

Thanks for Saturday games evenings, Friday SciFi DVDs, and lunchtime New York Times crosswords. Geeks and loving it! To Mort, Sue, Barbara, Klaus, Rogerio, Tim, Sylvia, Robin, Bennet, Atheer and Nick. For good food, good wine, good beer (!) and good company.

Thank you to my friends and family. For sanity, music and understanding, even when you're not really sure what I do everyday.

Lastly, thank you to Simon. Without you I might not have started along this route. Thank you for persuading me to do a PhD when I told myself I wasn't going to. Thank you for sharing this path with me.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES