PENGUIN ECTOPARASITES OF THE SOUTHERN HEMISPHERE

Rockhopper colony at the Murrell, Falkland Islands (taken by Katherine Moon)

REPORT TO THE SHACKLETON SCHOLARSHIP FUND

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1.0 INTRODUCTION

The role of long-distance dispersal in the composition and connectivity of Southern Ocean biota has long been debated (Queiroz 2005). While dispersal and ongoing gene flow is clearly a driving force of isolation and subsequent evolution of a species (Waters *et al* 2013.), the sporadic nature of such events often complicates their identification and investigation (Nathan 2006; Gillespie *et al.* 2012). However, via the increased application of molecular tools, there has been a resurgence of interest in the importance of dispersal is an evolutionary mechanism (Waters & Craw 2006). Recent molecular studies have found long-distance dispersal is capable of explaining the distributions of many varied species and lineages in the seemingly isolated Southern Ocean system.

Interestingly, genetic studies have implicated passive dispersal mechanisms in patterns of considerable movement in some non-motile species, such as via the winds (Muñoz *et al.* 2004) and oceanic currents (Fraser *et al.* 2009; Nikula *et al* 2013.). Species whose own dispersal capabilities are limited often rely on more active dispersers for their movement (Croteau 2010). In particular, parasites often rely on their hosts for dispersal (Dietrich *et al.* 2011). This interaction is an exceedingly intimate one, often equated to a permanent 'arms race' between host resistance and parasite virulence, both of which under extreme reciprocal selective pressure (Pérez‐Tris & Bensch 2005). While the faster mutation rates and generation times and higher reproductive capacities of parasites likely facilitate local adaptation (McCoy *et al.* 2002), the relative migration rates of host and parasite will also dictate the outcome of co-evolutionary adaptation in the system (Pérez‐Tris & Bensch 2005).

The seabird-tick system has received particular attention in recent years, especially in the Northern Hemisphere, as it provides an opportunity to assess the influence of highly motile hosts on the evolution of their terrestrial parasites. These studies have indicated that parasites can disperse with their flying hosts (McCoy *et al.* 2001; McCoy *et al* 2003.; McCoy *et al* 2005.; Kempf *et al* 2009.), but the physically isolating nature of seabird host behavior likely results in geographical and host-associated differentiation between tick populations (McCoy *et al.* 2001; McCoy *et al* 2003.; McCoy *et al.* 2005; McCoy *et al.* 2012). Almost all studies, however, have focused on flighted seabirds despite intriguing questions about how a terrestrial parasite might disperse with a largely aquatic host. Penguins (Spheniscidae) are flightless and primarily travel underwater, a dispersal mechanism that must present a considerable challenge to their ticks. Penguin ticks are widely considered unable to travel large distances with their hosts (Dietrich *et al.* 2011), though the extent to which this prevents movement is unknown. Regardless, these parasites rely on their highly vagile hosts for dispersal, and thus research into the geographical patterns of genetic divergence in the penguin tick could shed light on dispersal patterns and evolutionary relationships of the greater host-parasite system (Whiteman & Parker 2005).

While the academic significance of this knowledge is considerable, the parasitic nature of the tick is also responsible for a number of detrimental affects on its host. Penguin tick loads are known to be responsible for delays in chick growth, blood loss leading to anemia, toxin injection leading to paralysis (which has been specifically identified in some penguin ticks) and, in cases of hyper infestation, high tick loads may cause chick mortality (Frenot *et al.* 2001; McCoy *et al.* 2002; Heath 2006). These concerns, along with the increased presence and expansion of hard ticks due to climate change (Lindgren *et al.* 2000; Ogden *et al.* 2006; Danielová *et al* 2008.; Gern *et al.* 2008; Gilbert 2010; Lynch *et al* 2010.; Jore *et al.* 2011), and the threat these parasites pose to human health and industry (Jongejan & Uilenberg 2004) suggest that it is important to understand interactions that will potentially alter the evolutionary outcome for the host or parasite. This is especially important for species such as penguins, which are already under increased pressure from temperature changes and human-mediated stresses.

Given the need to understand this system, my project (see Appendix A), as partly funded by the Shackleton Scholarship Fund, aims to conduct genetic work on penguin ticks sampled from colonies representative of their full circumpolar distribution. More particularly, the Shackleton Scholarship funding awarded last year (2014) has given me the opportunity to personally collect samples from the Falkland Islands. This site is important in its own right (being home to large numbers of breeding penguins), but is also unique with regard to its physical setting in the Southern Ocean. The following is a review of the activities I have undertaken with the Shackleton Funds, as well as projections for the use of the samples collected and their publication.

2.0 Research activities

2.1 Sampling

In January of 2015, I visited the Falkland Islands to conduct the sampling activities outlined in my application. I decided that two weeks in the Falklands would be enough to sample four to five sites for penguin ticks. Prior to my arrival, I had many email and Skype discussions with with SAERI staff to ensure my trip would be as smooth as possible, with as many chances for samples as possible. Alas, I was only able to collect samples from three sites, due to a lack of ticks at sites (see below). However, the samples I did manage to collect were from a wide geographical area, and from comparable penguin species and thus are more than sufficient to answer the questions I have posed.

I arrived on the 17th of January, and was at Volunteer Point on the 18th. At Volunteer Point, I collected samples from king (~11 ticks) and gentoo (~45 ticks) penguins, from underneath rocks that surrounded the colonies. The conditions were not ideal, but the tick numbers were respectable.

On the 22nd of January, I was taken out to the Murrell by Adrian Lowe, and was able to take tick samples from two separate rockhopper colonies (total 22 ticks).

On the 24th of January, I flew out to Pebble Island and stayed for two nights (24th and 25th) to sample colonies. I collected samples from two fairly large rockhopper colonies, including one colony where I conducted some fine scale sampling, and both sites produced large numbers of ticks for my study (~116 ticks in total).

In addition to these sites where samples were taken, I also visited the gentoo colony at Bertha's Beach on the 29th, and looked at the gentoo colonies present on Pebble Island on the 25th. However, there were no ticks to be found at any of these gentoo sites. All natural gentoo colonies were clear of parasites in their nest habitat, and none were seen on any of the chicks or adults in and around the colony. Two ticks were found on the gentoo 'highway' from their colony to the shore at Pebble Island, but these may have been ticks from any animal. It may be that the movement of the colony every year has caused this lack of parasites, but this is unknown as yet. In addition, an attempt was made to collect samples from within the burrows of magellanic penguins, using a custom-made collection apparatus. This garnered no ticks.

2.2 Public involvement

In accordance with the advice given upon the scholarship offer, I publicized my work while in the Falklands, as well as upon my return. I gave a presentation to the SAERI group on the 30th, outlining my work and my objectives.

I also attended sessions as a part of the Falklands Science Symposium (from the 18th to 23rd), and made connections with many scientists in attendance with a view to collaborate.

More informally, I had the opportunity to talk to a number of locals (as well as other tourists particularly at Pebble Island) about my work. This includes the landowners of each site I sampled. In doing so, I feel that I involved myself in the wider community, and disseminated information not normally shared in a public forum.

Upon my return, I wrote a blog for the SAERI website (http://www.south-atlantic-research.org/blog/my-two-weeks-with-the-falkland-islands/) about my experiences in the Falklands, complete with pictures.

3.0 Next stages for project

The next stages for my PhD project will be the extraction of the DNA from the Falkland Islands tick samples. Following this, I will be conducting next-generation sequencing on the samples, before bioinformatics and data analysis.

During this time I will also be collecting samples from other sites to ensure significant coverage for my phylogeography study.

4.0 Projected outcomes and publications

The samples collected in the Falkland Islands will form a major part of two papers. The first will use the samples from the Falklands, as well as those collected around the globe, to investigate the phylogeography of penguin ticks.

The second will be a more theoretical paper detailing how dispersal influences evolution using the seabird-parasite system as a model for investigation.

Furthermore, there may be more papers based on my time in the Falklands. Time permitting, and assuming the validity of such comments, I may also write a short ecological note about the particulars of my sampling trip.

5.0 Budget review

Item(s)	**Income (AUD $)***	**Expenditure (AUD $)***
Shackleton Scholarship Fund	~4990	
Return flights to Chile		3288.68
Return flights to Mount Pleasant		1378.70
Return airport transfers		68.00
Return flights to Pebble Island		400.00
Accommodation on Pebble Island		199.00
Driver for day on Pebble Island (to take me to sample locations)		99.00
Total amount expended	$5433.38 (total value of SSF grant plus ~$445 research funding from within university as outlined in application)	

*NB- Figures are based on current conversion rates.

6.0 Conclusions

The Shackleton Scholarship Fund has not only allowed me to collect samples for my PhD from an important Southern Ocean site, but the opportunity to visit a location known for its unique ecological setting. I was able to collect a vast number of hard ticks from a number of penguin species not present near my own country. I was able to visit a region with a deep and interesting human history, while garnering a wider understanding of the penguin-tick system across the world.

I would therefore like to thank the Shackleton Scholarship Fund for this opportunity, as well as their continued support.

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8.0 Appendices

8.1 Appendix A: Context and research questions for the PhD project

The sampling undertaken with the Shackleton Scholarship Fund forms part of a PhD project at the Australian National University, Canberra, undertaken in close collaboration with Monash University in Melbourne. Here I have included the research questions I am to consider in my thesis, as these have changed slightly since my application was submitted.

Specifically, my PhD research will use novel genetic data, including data generated by cutting edge, 'next-generation' molecular technologies, to assess the following questions with regard to the ectoparasites of penguins in the Southern Hemisphere:

1. How connected are the biota of the sub-Antarctic region, and what drives this connectivity in the marine and terrestrial environments?
2. Can hard penguin ticks survive for extended periods of time in sea water and at penguin dive depths?
3. Do penguin ectoparasites exhibit significant genetic structure within a large colony?
4. Are penguin ectoparasites host-species specific?
5. Can terrestrial parasites travel with their aquatic hosts across vast (trans-oceanic) distances?