SCAR Fellowship 2008/09 Final Report

Title: The role of biotic and abiotic factors in determining the distribution of soil nematode communities in an Antarctic Dry Valley system

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Supervisor: Dr. Byron Adams

Introduction

The influence of biotic factors in determining the spatial distribution and structure of soil nematode communities within the McMurdo Dry Valleys, Ross Dependency has been an integral part of the Long Term Ecological Research (LTER) Program (NSF Award ANT-0423595). Through controlled experimentation and quantitative sampling, factors such as total carbon, salinity, elevation and soil moisture have been identified as directly influencing both the abundance and diversity of soil nematode populations (Treonis et al. 1999, Courtright et al 2001). However, the role of biotic interactions and their combined influence on soil nematode populations has received very little attention (Hogg et al. 2006). To try and ameliorate this lack of knowledge this research aimed to:

1) Attempt to identify biotic and abiotic factors that may influence the spatial distribution and diversity of the three soil nematode species (*Scottnema lindsayae, Eudorylaimus antarcticus* and *Plectus murrayi*) within the study area.

2) Develop an interdisciplinary GIS model of our Southern McMurdo Dry Valleys study area (i.e. Garwood, Marshall, Miers).

Methodology

This research was carried out as part of the New Zealand Terrestrial Biocomplexity survey (nztabs.ictar.aq) Antarctica New Zealand project # K020; focused on a 52 km^2 ice free habitat encompassing Garwood, Marshall and Miers Valleys (Fig. 1). The study area was divided into 500 sample sites based on unique physical and geomorphologic characteristics (Fig. 2). At each sample site soil samples were collected and analysed for moisture content (%), total DNA concentration (ng/g soil), conductivity (mS), C:N (% w/w), pH and soil micro invertebrates using standard protocols. In addition the presence and relative abundance of moss, lichen and cyanobacterial cover were estimated. Soil

invertebrates were extracted via sugar centrifugation as described by Freckman et al. (1977). Nematodes were counted and identified under 200X magnification. Each sample site was also surveyed for the presence of other free-living terrestrial invertebrates (i.e. springtails/mites).

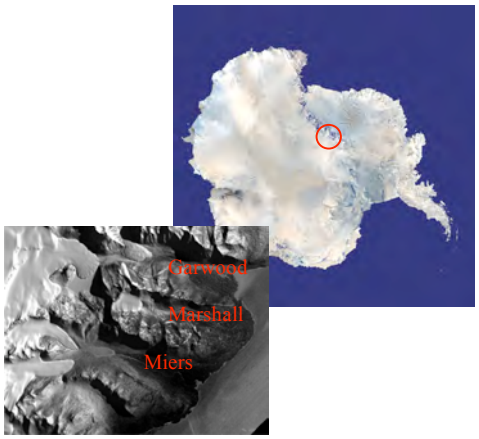

Fig. 1 Location of the study area relative to the Antarctic continent. Inset graphic of the 52 km^2 ice free habitat encompassing Garwood, Marshall and Miers Valleys.

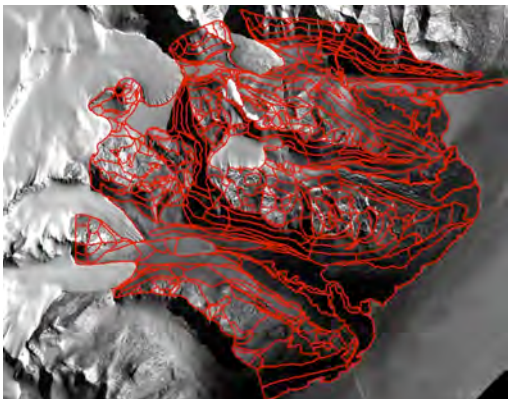

Fig. 2 Overlay of the 500 individual sample sites located throughout the study area.

Results

Of the 500 proposed sample sites, 497 were successfully surveyed. Of the 698,355 nematodes collected 84.6% were identified as *Scottnema lindsayae* from 379 sites (Fig. 3). *Eudorylaimus antarcticus* comprised over 8.22% of the total catch from 258 sites (Fig. 4) while *Plectus murrayi* comprised over 7.18% of the total catch from just 61 sites (Fig. 5).

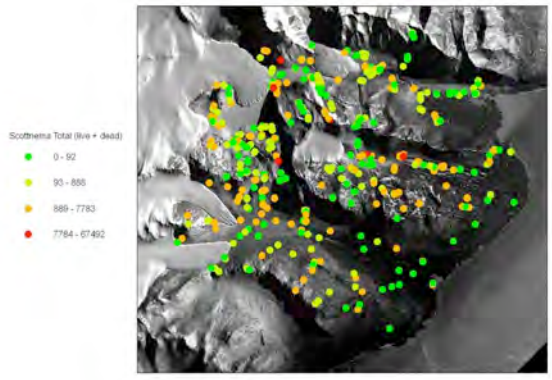

Fig. 3 Distribution of *S. lindsayae* throughout the study area.

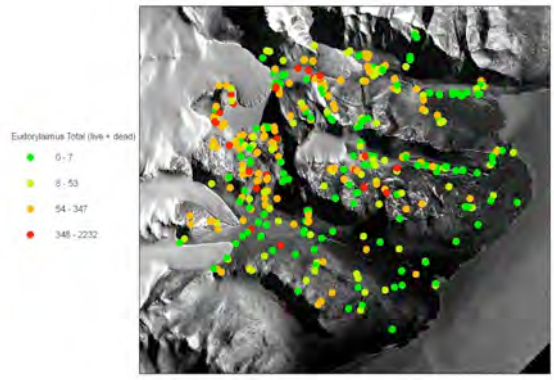

Fig. 4 Distribution of *E. antarcticus* throughout the study area.

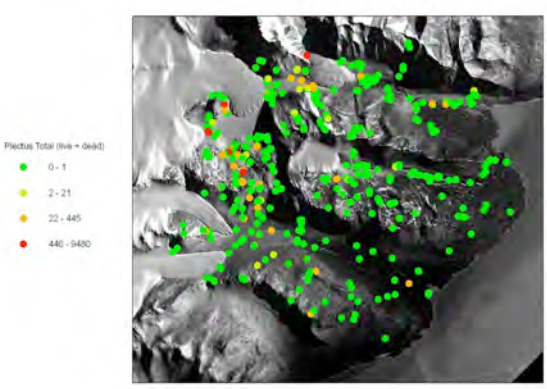

Fig. 5 Distribution of *P. murrayi* throughout the study area

Soil Moisture

Soil moisture throughout the study area ranged from a low of 0.29% w/w to a high of 38.42%; mean 5.22% (STD = 5.23). Soil moisture was a poor predictor of species occurrence and abundance for *S. lindsayae* and *E. antarcticus* explaining just 0.8% and 0.7% of the variance respectively. However, soil moisture was a much better indicator of both *P.* presence and abundance showing a positive linear relationship explaining 10.6% of the variance. In general population numbers of *S. lindsayae* showed a declining trend with increasing soil moisture while both *E. antarcticus* and *P. murrayi* population numbers showed an increasing trend.

Soil DNA Concentration

Total soil DNA concentration measured in ng/g of soil and was used as a proxy for total soil biomass. Total soil DNA concentration throughout the study area ranged from 0.0 to 4626.3 with a mean value of 586.53 and a standard deviation of 552.4. Interestingly the largest values for total soil DNA did not relate to the sites with highest nematode abundance suggesting that nematodes make up a small proportion of the total DNA concentration of the soil. Nematode abundance showed a positive linear relationship for all three species of nematode when plotted against total soil DNA concentration. Soil DNA concentration accounted for 6.3%, 10.5% and 3.6% of the variation of *S. lindsayae*, *E. antarcticus* and *P. murrayi* respectively.

Conductivity

Soil conductivity measured in millisiemens (mS), used as a proxy for soil salinity, ranged in value from 0.001 to 8.330 mS with a mean value of 0.323 mS and a standard deviation of 0.844 mS. Soil conductivity was a very poor predictor of nematode abundance showing a negative linear relationship which accounted for less than 0.5% of the variance. However, soil conductivity was a useful predictor of nematode species occurence. *S. lindsayae* was found in soils with a conductivity up to 4.26 mS while *E. antarcticus* and *P. murrayi* only occurred in soils with a conductivity less than 1.98 mS and 2.09 mS respectively.

Carbon:Nitrogen

Carbon and nitrogen were both measured in % w/w of dry soil and ranged in value from 0.39711% to 0.00033% for nitrogen with a mean value of .00874% and a standard deviation of 0.01996%. Soil Carbon ranged from a maximum of 5.70583% to 0.00058% with a standard deviation of 0.57071%. C:N ratios ranged from 334.07313 to 1.78099 with a standard deviation of 43.53066. There was no correlation between nematode abundance with changing levels of C and N. However, *E. antarcticus* and *P. murrayi* only occured in soils with a C:N of less than 148 while *S. lindsayae* were present in soils with a C:N as high as 301.

pH

Soil pH ranged from 5.08-10.34 with a mean value of 8.61 and a standard deviation of 0.69. There were no nematodes of any species collected from soils with a pH of 6.4 or less. *S. lindsayae* showed a wide soil pH preference ranging from 6-10 with highest mean abundance occurring around pH 9. *E. antarcticus* showed a soil pH preference range between 7-10 with highest mean abundance occurring at pH 8. *P. murrayi* showed a soil pH preference range between 7-9 with highest mean abundance occurring at pH 7.

Moss/Lichen/Cyanobacterial Ground Cover

Moss, lichen and cyanobacterial ground cover throughout the study area was highly variable and showed no relationship to either nematode abundance or distribution. A much better measurement for these variables may come from molecular analysis of the soil samples that will more accurately identify the presence and amount of cyanobacteria, lichen and/or moss per sample site.

Relevance to Project Aims

The main aim of this research was to identify biotic, in addition to abiotic factors, which influence the abundance and distribution of nematodes in the McMurdo Dry Valleys. This study found several variables that were related to nematode abundance as well as distribution throughout our study area. Total soil DNA concentration was the best biotic indicator of soil nematode abundance in this study. Increased soil DNA concentration may relate to high levels of bacteria and fungi that make up the forage base of all three species of nematode in our study area. It is unlikely that increased soil DNA concentration related simply to high amounts of nematode DNA due to the differing degree in which different nematode species responded. Of the abiotic factors measured soil moisture was the best indicator of soil nematode abundance and occurrence throughout the study area. *S. lindsayae* showed the greatest tolerance to varying levels of soil moisture exhibiting a range of 0.34% - 20.0 % w/w. However, *S. lindsayae* abundance showed a declining trend with increased levels of soil moisture. Conversely, both *E. antarcticus* and *P. murrayi* abundance increased with increasing levels of soil

moisture. Soil conductivity, which was used as a proxy for soil salinity, did not correlate to nematode abundance. However, soil salinity was a good predictor of nematode species occurrence. Again, *S. lindsayae* populations showed a wide range of soil salinity tolerance being found in soils ranging from 0.001 mS to 4.26 mS while both *E. antarcticus* and *P. murrayi* were only found in soils with a conductivity less than 2.09 mS. Measurements of soil pH were both a good predictor of nematode abundance and occurrence. In general *S. lindsayae* was present in soils ranging from pH 6-10 with highest mean abundance between pH 9 and 10. *E. antarcticus* preferred was present in soil ranging from pH 7-10 with highest mean abundances between pH 8 and 9. *P. murrayi* showed the smallest soil pH range of 7-9 with the highest mean abundance between pH 7-8. Carbon and nitrogen soil levels (expressed as % dry weight of soil) were not good predictors of nematode abundance or occurrence. However, the ration of carbon and nitrogen was a good indicator of nematode occurrence throughout the study area. In general *S. lindsayae* was found in soils with a C:N ratio ranging from 1.72 to 274 while both *E. antarcticus* and *P. murrayi* were found in soils with a C:N ratio no greater than 148.

These findings suggest that biotic factors such as available forage (i.e. soil DNA concentration) control nematode abundance while abiotic factors such as soil moisture, salinity etc. control nematode distribution. In general we found *S. lindsayae* to be the dominant nematode throughout our study area, able to withstand the greatest amount of environmental variables, while both *E. antarcticus* and *P. murrayi* became the dominant nematodes at high soil moisture levels (i.e. >21% w/w). In addition, the life history (i.e. fecundity, generation time, generalist nature) of *S. lindsayae* may result in a competitive advantage over both *E. antarcticus* and *P. murrayi* in environments that may be hospitable for all three species. Though not specifically tested for, this biotic interaction may be the reason for the sheer dominance of *S. lindsayae* throughout our study area. However, at present very little is known of the life history of Antarctic nematodes.

Currently, a GIS based interdisciplinary model of the southern McMurdo Dry Valleys incorporating a myriad of biological, geological and meteorological data is being constructed at the University of Waikato. Ground truthing of the preliminary GIS model began last Antarctic field season (2010/11) and will continue this field season (2011/12). The final completion and publication of this model is anticipated in the near future.

In addition to our work on nematodes we were able to compile a significant collection of both the Antarctic springtail *Gompheocephalus hodgsoni* and the mite *Stereotydeus mollis.* In collaboration with my co-supervisor, Dr. Byron Adams, this led to the production of a MSc thesis at the University of Waikato, a scholarly publication in the peer reviewed journal *Antarctic Science* and numerous conference presentations.

Outputs

nzTABS website available at: http://nztabs.ictar.aq/

Demetras, N.J. 2010. Phylogeography and Genetic Diversity of Terrestrial Arthropods From the Ross Dependency, Antarctica. MSc thesis. University of Waikato, Hamilton, New Zealand. http://researchcommons.waikato.ac.nz/bitstream/10289/4291/1/thesis.pdf

Demetras, N.J., Hogg, I.D., Banks, J.C., Adams, B.J. 2010. Latitudinal distribution and mitochonrial DNA (COI) variability of *Stereotydeus spp.* (Acari: Prostigmata) in Victoria Land and the central Transantarctic Mountains. *Antarctic Science* Vol. 22: 749-756. DOI: 10.1017/S0954102010000659

Demetras, N.J., Hogg, I.D., Banks, J.C. 2010. Fine-scale genetic diversity for two terrestrial arthropods in the Southern Dry Valleys, Ross Dependency. 2010 Annual Antarctica NZ Conference. Christchurch, NZ. Oral Presentation.

Demetras, N.J., Hogg, I.D., Stevens, M.I., Ross, P.M., Banks, J.C., Cary, S.C. 2009. Distribution of mtDNA haplotypes for the springtail *Gomphiocephalus hodgsoni* relative to physical, chemical and biological characteristics in the southern Dry Valleys, Victoria Land. Xth SCAR International Biology Symposium. Sapporo, Japan. Oral Presentation.

Budget Justification

Item	USD
Return Airfare: Air New Zealand Auckland, NZ - Denver, CO, USA,	
Regional Return Airfare:	2500
Denver, CO, USA – Salt Lake City, UT, USA	500
Accomodation \$85 day^{-1} x 30	2550
Meals/Incidentals \$40 day^{-1} x 30	1200
Transportation (Airport shuttle, Buses, Taxis etc.)	500
Total	7250

Literature Cited

Courtright, E.M., Wall D.H., Virginia R.A. 2001. Determining habitat suitability for soil invertebrates in an extreme environment: the McMurdo Dry Valleys, Antarctica. *Antarctic Science*. Vol. 13(1):9-17

Freckman, D.W., Kaplan, D.T., and van Gundy, S.D. (1977) A comparison of techniques for extraction and study of anhydrobiotic nematodes from dry soils. *Journal of Nematology*. Vol. 9: 176-181

Hogg, I.D., Cary, S.C., Convey, P., Newsham, K.K., O'Donnell, A.G., Adams, B.J., Aislabie, J., Frati, F., Stevens, M.I., Wall, D.H. 2006. Biotic interactions in Antarctic terrestrial ecosystems: Are the a factor? *Soil Biology and Biochemistry*. Vol. 38(10): 3035-3040