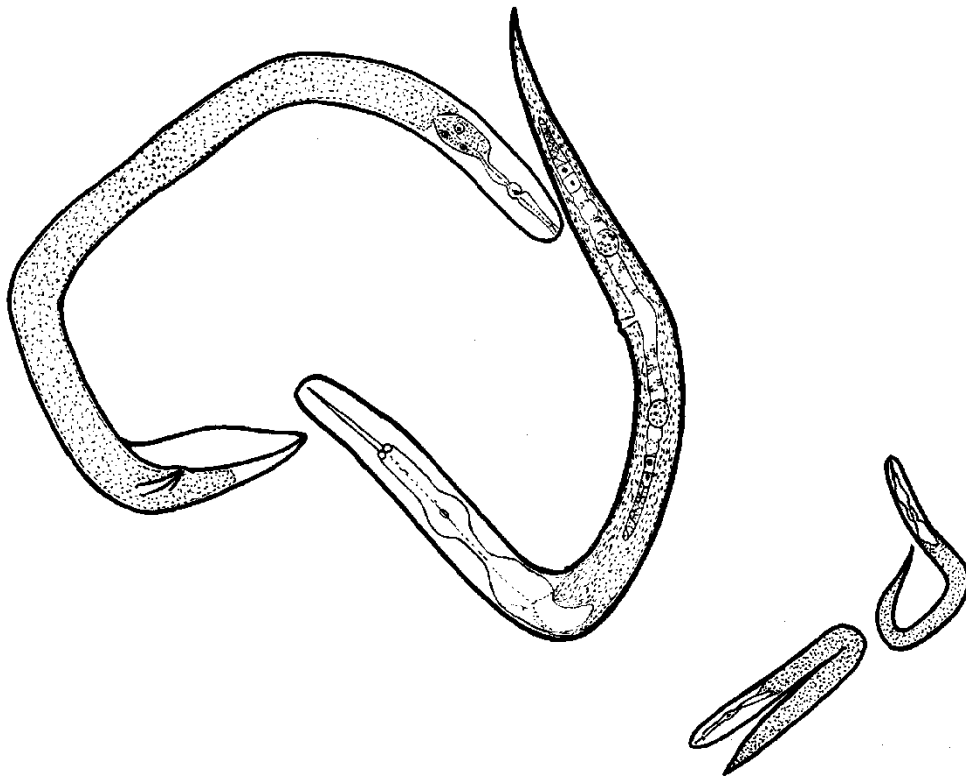


AUSTRALASIAN NEMATODOLOGY NEWSLETTER



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From the Editor

Thank you to those of you who made contributions to this current newsletter.

January Issue

The deadline for the January issue will be late December 2012. I will notify you a month in advance so please have your material ready then.

Kerrie Davies

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Association News

FROM THE PRESIDENT

It is a pleasure to be able to open a report with a positive story, especially in a time of general gloom for science. The positive story is that the Australian Nematology Support Fund (the remaining funds from 5ICN) was able to provide substantial support for 3 Australian students to attend the 6th ICN. The reports from these people will be presented elsewhere. From what I saw, all gained quite a bit from attending: from contacts with people elsewhere in the world who can provide or exchange data; from hearing about a number of different areas of nematology that they would not normally be exposed to; from the experience of presenting to a different, specialist audience seldom occurring in Australia; and just from getting something completely different from their focussed University studies.

For myself, I found the 6th ICN very interesting; mostly from learning what other people were doing differently and what was the same. A major issue that is the same is the concerns about what is a nematode 'species', which is close to my taxonomic work. Work coming out of Germany, the USA and South America all points to this being a seriously complex issue, with some groups that we thought were species showing a lot of underlying similarity, but more commonly groups of nematodes that are superficially very similar being substantially different in many ways. Perhaps the biggest difference for me was the realisation that there is a lot of basic nematology on the relationships between plants and nematodes that is not very high-tech going on in many parts of the world.

The ICN provides the opportunity for the representatives of the members of the International Federation of Nematology Societies to get together (the societies themselves are the members of IFNS). At this meeting, we thanked the outgoing officers, Wilfrida Decraemer (President), Rosa Manzanilla-Lopez (Vice-President) and Safia Siddiqi (Secretary-Treasurer). The new officers are Larry Duncan from the SON (President), Ernesto San Blas from the Venezuelan Society (Vice-President) and Andreas Westphal from ESN (Secretary-Treasurer). There was also some discussion about the level of formality of the structure of the International Federation, and in the end, the potential administrative costs of time and money in establishing and then maintaining a formal structure were seen by the majority of societies as outweighing the benefit of being a financial entity able to obtain and hold funds. This more or less parallels the discussions we have had at AAN over a formal structure. (For information, the AAN has no formal (written) structure, but 5ICN (now the Nematology Support Fund) does have a formal structure because it hold funds.)

If there are any questions about this, please get in touch.

Mike Hodda



Sunil Singh, Natalie Banks, Nuchanart Tangchitsomkid, and Mike Hodda enjoying the South African scenery during the 6th ICN.

Regional News

NEWS FROM THE ACT

CSIRO Ecosystem Sciences

The PhD thesis of Sunil Singh was formally passed by Charles Sturt University in April. Congratulations Sunil.

Natalie and Mike spent most of February and March travelling in Thailand, Laos and Cambodia, collecting on farms and markets, and teaching the locals, with long-term collaborator Dr Nuchanart Tangchitsomkid from Thai Department of Agriculture and Mr Thanakorn Chanmalee from Kasetsart University. A highlight for Mike was giving the first ever lecture on Nematology at the Royal University of Agriculture in Phnom Penh (see picture). There were at least 50 keen students for what was an optional lecture, which was pretty good.

Natalie has also been sampling in Australian farms and markets. Her PhD continues on track and she has now submitted another paper for publication on what the different characteristics of trade networks may mean for the transmission of plant pathogens.

Other news is that Mike's paper on the new species of *Pratylenchus* from WA is finally close to publication. Hopefully it will appear soon after this publication. After all the time spent on this after too many years, the morphological, molecular, biological and ecological evidence for a new species was, we thought, compelling.

Mike's other student Kylie Crampton at CSU has set up field trials of her most promising as well as doing lab test of interactions between different biocontrol agents.

Finally, it was a busy time preparing for the 6th ICN. In the end the group presented a total of 5 talks and 2 posters (Mike one on biodiversity and one on teaching, Sunil one on biosecurity, Natalie one on biosecurity, Kylie one on biocontrol, and Mike two posters on methods).

In addition to all this we have all been busy with routine matters. This has included a complete internal re-structure of CSIRO. For those that want to know, Mike will officially be part of the CSIRO National Biological and Reference Collections Facility from July 1, but will continue to be actively involved in the Biosecurity Flagship as well.



Mike Hodda.

NEWS FROM QUEENSLAND

Biological Crop Protection

One major job finished: time for other things! This is just a quick note to let colleagues know that I am no longer spending all day in front of a computer. My new book was finished last year and published in May, so there has been time to do other things in 2014. Some of the highlights include:

- A trip through the WA wheat belt in early February. A group of scientists involved in the GRDC Soil Biology Initiative drove from Ravensthorpe to Geraldton and spoke to five groups of growers and their consultants about what we had learnt during the last few years.
- A trip to The University of Sydney in March to give my annual nematology lecture and lab. to plant pathology students.
- A visit to Adelaide in April to help Katherine Linsell set up some experiments on suppression of *Pratylenchus* in cereal soils. One of the most interesting findings was a field in the mid north of SA with 50 free-living nematodes/g soil. That is by far the highest nematode count I have ever seen in a cereal-growing soil, and suggests that the farming system being used in that part of Australia is beginning to improve the soil's biological status.
- A trip to Cape Town to attend the Sixth International Congress of Nematology, and give two talks, one on soil health and the other on resistance of *Erianthus* (a wild relative of sugarcane) to *Pratylenchus* and *Meloidogyne*. Although it was great to be able attend the Congress, the meeting paled into insignificance compared with the elephants, rhinos, giraffes, lions, buffaloes, zebras etc. etc. we saw in the following two weeks. Marcelle and I visited seven national parks in Kenya and Tanzania (Meru, Nakuru, Masai Mara, Lake Manyara, Serengeti, Ngorongoro and Lake Tarangire) and we can recommend them all.
- A letter from Sugar Research Australia in May indicating that my application for research funding had been successful. The new project starts on 1 July 2014, and is entitled "Regenerating a soil food web capable of improving soil health and reducing losses from soilborne pests and pathogens of sugarcane". One of the

exciting things about this project is that funds are available to train two young plant pathologists in soil biology.

- A meeting with Australian and overseas scientists in Melbourne in June to consider options for improving diagnostic and predictive services for soilborne pathogens of vegetables. One of the most pleasing features of the meeting was that the sponsor (AusVeg) asked the group to consider the possibility of including beneficial organisms in the suite of tests that may eventually be developed.
- A trip to Cairns in June, where I attended the annual AusVeg conference and gave a talk entitled “Integrated management of root-knot nematode on vegetable crops”.
- A new extension bulletin entitled “Management of root-knot nematode in vegetable crops“ was finally completed in June. Prepared by Frank Hay and myself, it was one of the outcomes of a national vegetable nematology project funded by Horticulture Australia Limited. The bulletin can be accessed at the Tasmania Institute of Agriculture website.

For those with an interest in the many fascinating organisms that coexist with nematodes in soil, you might like to read my new book. The following summary (which can be found on the back cover) provides an indication of the contents.

‘Crop-based agriculture depends on healthy soil, and plant-parasitic nematodes are one of the major causes of soil-related sub-optimal crop performance. Biological control, an important component of all nematode management programmes, is vital to maximising crop output.

This book provides holistic solutions to nematode problems by integrating information on soil health and sustainable agriculture with our ever-expanding knowledge of nematode ecology and the suppressive services provided by the soil food web. With a particular focus on integrated soil biology management, it describes the tools available to farmers to enhance the activity of natural enemies and utilize soil biological processes to reduce losses from nematodes. The key role of organic matter in improving the physical and chemical fertility of soil, and enhancing biological suppressiveness to nematodes, is a theme that runs throughout the book. A full section on suppression of nematodes through natural means is included, while the book also discusses plant-microbial symbiont-nematode interactions, and examines the potential of various biopesticides that are being developed for use against nematodes. With a final summary section reviewing practical control approaches and areas for future research, this book provides a valuable resource for researchers and students of plant nematology, soil ecology and soil microbiology. It will also prove useful to extension personnel, pest management consultants and farmers who wish to improve their understanding of the soil biological processes that underpin sustainable agriculture’.

Stirling G.R. (2014). *Biological Control of Plant-parasitic Nematodes: Ecosystem Management in Sustainable Agriculture*. CAB International, Wallingford. 510 pp. ISBN 978-1-78064-415-8.

Graham Stirling

NEWS FROM SOUTH AUSTRALIA

SARDI

SARDI has a number of Nematology projects within the Sustainable Systems division.

The collaborative project between Katherine Linsell from SARDI and Graham and Marcelle Stirling from Biological Crop Protection is finishing up. The project developed

DNA tests for the rapid assessment of free-living nematode communities in Australian cropping soils and will be available through SARDI's PreDicta B soil testing service. It is a part of GRDC's Soil Biology Initiative and we hope to receive more funding in the third round of this initiative beginning in June 2015.

Katherine presented the outcomes from this project in a talk titled 'DNA Assays for Free Living Nematodes - Indicators of the Biological Status of Australian Cereal Soils' at the 6ICN in Cape Town in May in the Nematodes and Soil Health sessions chaired by Howard Ferris and Mario Tenuta. Graham Stirling also gave a talk in this session about his work on how a new sugarcane farming system improves soil health and enhances suppressiveness to plant-parasitic nematodes. There were many other interesting projects outlining the effects of various farming systems on biological soil health and discussions on the usefulness of community indices.



Alan McKay, in collaboration with DEPI Horsham, is continuing to work on a GRDC-funded project screening cereal cultivars for resistance and tolerance to the root lesion nematodes (*Pratylenchus thornei* and *P. neglectus*) in the field. In 2014, six trials were planted in SA, three to test the tolerance of current and newly released cereal varieties to *P. neglectus* this year and three in the initial phase for evaluation next year. Sjaan Davey has left the Nematology group to work in SARDI's Farming Systems group and so Paul Bogacki and Katherine Linsell have now taken on this project.

Paul Bogacki continues to investigate the effects of break crops including canola, field pea, lentil, chickpea, triticale and oats on *P. neglectus* and *P. thornei* multiplication, as part of a 5 year project funded by GRDC. Each year five NVT trials are intensively sampled and changes in RLN levels are monitored using PreDictaB.

Sue Pederick and Jackie Nobbs have been busy with SARDI's Seed and Plant Pathology Diagnostic Services. There has been a gradual increase in the number of samples sent for analysis in the last six months that require both identification of plant parasitic nematodes (mainly root lesion nematodes) and total free living nematode. This suggests that farmers are interested in knowing more about the nematode fauna of their soil. Growers want identification of plant parasitic nematodes to species level as it allows for more successful planning of crop rotations and reduction of disease. In addition, knowledge of the level of

fungal and bacterial feeders could be an indication of the presence of fungal and bacterial diseases within a soil.

Katherine has finally published her work from her PhD and is now co-supervising a PhD student, Shefat Rahman, who is fine mapping the *P. thornei* resistance loci, *QRInt.sk-2B* and *QRInt.sk-6D* identified in her thesis. Shefat is also investigating further the biological resistance mechanisms using histochemical staining and microscopy.

Publications:

Linsell KJ, Rahman MS, Taylor JD, Davey RS, Gogel BJ, Wallwork H, Forrest KL, Hayden MJ, Taylor SP, Oldach KH. (2014) QTL for resistance to root lesion nematode (*Pratylenchus thornei*) from a synthetic hexaploid wheat source. *Theoretical and Applied Genet.* 127, 1409-21.

Linsell, KJ, Riley, IT, Davies, KA, Oldach, KH. (2014) Characterization of resistance to *Pratylenchus thornei* (Nematoda) in wheat (*Triticum aestivum*): attraction, penetration, motility, and reproduction. *Phytopathology* 104, 174-187.

Katherine Linsell

The University of Adelaide

The review of *Fergusobia* was finally completed, accepted and is out:

Nelson LA, Davies KA, Scheffer SJ, Taylor GS, Purcell MF, Giblin-Davis RM, Thornhill AH, & Yeates DK (2014). The fly-nematode mutualism on Myrtaceae host plants: an emerging example of tritrophic coevolution (Diptera: Fergusoninidae; Nematoda: Neotylenchidae). *Biological Journal of the Linnaean Society* 111, 699-718.

With 'Fred' Bartholomaeus, Kerrie has been working on a revision of the genus '*Schistonchus*', which is polyphyletic. They are currently completing a manuscript splitting '*Schistonchus*' into three genera. Along the way, they have fallen foul of a recurring problem in nematode systematics – that of cryptic species (for '*Schistonchus*', substitute cryptic 'genera'). One genus separates off 'beautifully', but while the molecular data shows that the other two are clearly separate, morphologically there is too much overlap (using current data) between them to be able to find clear apomorphies. SEM will be critical in future studies.

John Sagun (Darwin) will visit the lab. again in July to work on his Master's project on entomophilic nematodes (*Heterorhabditis*). He is a part-time, external student enrolled at Ateneo de Manila University. John has found a new species of *Heterorhabditis* in the Darwin area, and is describing it.

Kerrie Davies

NEWS FROM VICTORIA

DEPI Horsham

Nematology activity at DEPI Horsham has been steadily increasing over the last few years. Currently, there are two dedicated nematology projects and nematology trials within another yield loss project. With the increase in the number of projects, the number of trials has increased from 13 in 2013 to 25 in 2014.

The root lesion nematode (*Pratylenchus thornei* and *P. neglectus*) projects now include screening of pulses and canola for tolerance in addition to screening of pulses for resistance and cereals for tolerance and resistance, which was previously the primary focus. In 2014, trials have been sown to manipulate and establish high and low densities of both *P. thornei* and *P. neglectus*. These plots will allow yield loss to be assessed in field peas, lentils, chickpeas, canola and cereals in 2015. Screening of current and past varieties for tolerance and resistance is continuing in cereals, field leas and lentils, with additional trials sown to evaluate resistance in chickpeas.

Results on losses due to *P. neglectus* have shown minimal yield loss in the Wimmera, and as a result the Birchip Cropping Group have been contracted to run trials in the Victorian Mallee on behalf of DEPI. With the Victorian Mallee a dominant cropping area these trials will complement the trials in the Wimmera, and allow for yield loss comparisons in areas where water is more limiting and the soils are shallower. Information on nematode densities prior to and following each crop are being quantified using the PreDicta B DNA assay at SARDI. The trial results are being incorporated into field crop disease guides, assisting growers to manage populations of *P. thornei* and *P. neglectus* and the losses associated with these nematodes in their soils.

Joshua Fanning, Mathew Rodda and Grant Holloway

NEWS FROM WESTERN AUSTRALIA

Murdoch University

The group at Murdoch University studying plant nematology is part of the Plant Biotechnology Research Group and is based in the WA State Agricultural Biotechnology Centre (SABC). The plant nematology and aphid group consists of the following researchers:

Prof Mike Jones

Dr John Fosu-Nyarko

Dr Leila Eshraghi (until Dec 2013)

A/Prof Derek Goto (Distinguished Collaborator: Hokkaido University; moving to be a Research Director at KWS)

Dr Uma Rao (Indian Agricultural Research Institute) Australia-India Strategic Research Fund Project (now completed from the Australian side)

PhD students Paul Nicol, Jo-Anne Tan, Sadia Iqbal, Harshini Herath, Malathy Rathinasamy, Fareeha Naz, and Farhana Begum (with Shashi Sharma, now at Murdoch, and Bill McCleod, DAFWA). We also have Vineeta Bilgi and Silvee Rahman, working on aphid-plant responses.

The nematode work is concentrated on the molecular basis of nematode-plant interactions and use of new approaches for nematode control. One focus is on root lesion nematodes and is described in the following publication:

Jo-Anne C.H. Tan, Michael G.K. Jones, John Fosu-Nyarko (2013). Gene silencing in root lesion nematodes (*Pratylenchus* spp.) significantly reduces reproduction in a plant host. *Experimental Parasitology* **133**, 166–178

We are proud of Jo-Anne's paper which is the most detailed study on gene silencing in root lesion nematodes. From it, we conclude that gene silencing (RNA interference) is a potential control strategy for root lesion nematodes.

The following paper came out of collaboration with the European groups (via COST ACTION 872). It is one of a series on top ten plant pathogens, with our contribution being on root lesion nematodes:

Jones, JT, Haegmen, A, Danchin, EGJ, Gaur HS, Helders, J, Jones MGK, Kikuchi, T, Manzabill-Lopez, R, Palomares-Ruis, JE, Wesmael, WML and Perry RN (2013). Top 10 plant parasitic nematodes in molecular plant pathology. *Molecular Plant Pathology* **14**, 946-961. DOI: 10.1111/mpp.12057

In other areas, John Fosu-Nyarko continues to be the mainstay in the lab, and is involved in most research projects. Paul Nicol is writing up his thesis, which has a bioinformatics focus including analysis of transcriptomes of *P. zaeae* and the J2 stage of *Heterodera schachtii*. Sadia and Harshini are undertaking detailed studies on different metabolic pathways in root-knot and cyst nematodes as potential targets for control, and Malathy and Fareeha are studying small RNAs in relation to gene silencing and new methods of delivery. Farhana is jointly supervised by Shashi Sharma and Bill McCleod (DAFWA) and will be working on more applied aspects of root lesion nematodes. Leila has developed 'hairy root' systems for potential nematode maintenance and testing. We will update these projects as the work proceeds to publications – there are quite a few in the pipeline!

One of the six most influential papers in Annals of Applied Biology in the past century

In 2014, the journal 'Annals of Applied Biology' is publishing its Centenary Edition. The journal Editors decided that six papers should be identified as 'the most influential' published in the journal in the last 100 years. One was to be discussed in each of the 6 issues for 2014, with an editorial describing the significance of the original paper. One of those selected was the article entitled 'Host cell responses to endoparasitic nematode attack: structure and function of giant cells and syncytia' (*Annals of Applied Biology* **97**, 353-372, 1981), written by Mike. As a result, the journal requested Mike to write another review on any subject of his choosing. This review has now been published, co-authored with Dr John Fosu-Nyarko (Jones M.G.K. & Fosu-Nyarko J. 'Molecular biology of root lesion nematodes (*Pratylenchus* spp.) and their interaction with host plants' *Annals of Applied Biology*, **164**, 163–181) – hopefully it will achieve the same status as Jones (1981), although Mike is unlikely to be around for the bicentenary of the journal!

This review was published with a preceding editorial by I.G. Grove and R.N. Perry: The important legacy of the paper by Jones M.G.K. (1981). Host cell responses to endoparasitic nematode attack: structure and function of giant cells and syncytia. *Annals of Applied Biology* **164** (2014) 159–162.

International links In 2013, Mike visited India and gave a plenary address at an International Meeting at Kakatiya University (Warangal, AP) and visited Dr Uma Rao at IARI and other researchers at Delhi University (South Campus, two meetings with keynote talks) to discuss joint research and publications. The following is an outcome of the AIRSF grant between Mike and Uma's groups, the first transcriptome data on the cereal cyst nematode, *H. avenae*:

Mukesh Kumar, Nagavara Prasad Gantasala, Tanmoy Roychowdhury, Prasoon Kumar Thakur, Prakash Banakar, Rohit N Shukla, Michael G. K. Jones and Uma Rao (2014). De Novo Transcriptome Sequencing and Analysis of the Cereal Cyst Nematode, *Heterodera avenae*. *PLOS One* DOI: 10.1371/journal.pone.009631

In May, as part of a short trip to the USA, Mike visited Professor Eric (Rick) Davis at Raleigh, NCSU, USA who is focussing on analysing what nematode effectors interact with in host plant cells.

As a ‘Distinguished Collaborator’, A/Professor Derek Goto (who has now changed his name back to Derek Bartlem) from Hokkaido University has visited the group in Perth four times in the last year. His focus is on host responses to *Meloidogyne hapla*, and on molecular events involved in giant cell formation and plant responses to nematode infestation. Here is an outcome of the collaboration with Derek:

Derek G. Bartlem, Michael G. K. Jones and Ulrich Z. Hammes (2014). Vascularization and nutrient delivery at root-knot nematode feeding sites in host roots *J. Exp. Bot.* **65**, 1789-1798 doi: 10.1093/jxb/ert415

Derek went to School in South Hedland and was a former student of Mike’s at Murdoch University: now that he has his own lab at Hokkaido University and with his postdoctoral experience at Cold Spring harbour Laboratory in the USA, where he rubbed shoulders with the likes of James Watson, we can predict that he will become a new force in this field. (Note: I wrote this for the last AAN Newsletter, and my prediction of great things for Derek eventuated faster than I thought – he will be running a new research centre to be established in St Louis USA for the German plant breeding company KWS – if he can’t keep up his research interests it will be a major loss to plant nematology).

Mike was an invited speaker at the Oxford Global Congress in London (May 2014) on Food, Nutrition and Agriculture Genomics where he gave a keynote address on ‘Application of Gene Silencing Technology to Crop Improvement’.

Mike also attended the 6th ICN Meeting in Cape Town, where he co-organised and co-chaired two sessions with Godelieve Gheysen from Ghent on nematode genomics. His talk was entitled: ‘Candidate secreted proteins and effectors of *Pratylenchus* spp.’ There were some very interesting presentations in this area – one observation from David Bird (NCSU) was that root knot J2s infect most just after dawn, and if they fail to induce giant cells, they have to wait for 24 hours until conditions (diurnal changes in plant metabolism) are favourable. There were many updates on nematode effectors, with a focus now on understanding what plant components they interact with. In this area, the field of nematode-plant interactions is advancing rapidly, with some excellent hard core science.

When in South Africa, a visit to the vineyards near Stellenbosch is a must, as is a visit to the Cape of Good Hope (the South-western most tip of Africa, but not the most southerly point!).



L-R, and top to bottom – Table Mountain, the only time it wasn't covered in cloud; vineyard; springbok for lunch; Godelieve Gheyen and Tina Kyndt; the Boot dance; Manuel Motta and Paulo Vieira

Mike Jones

NEWS FROM NEW ZEALAND

LandCare Research

In May 2014, Zeng Zhao attended the 6th International Congress of Nematology in Cape Town in South Africa. About five hundred delegates attended the Congress from all over the world and Zeng Zhao was one of three lucky delegates from New Zealand. He presented a paper on behalf of Landcare Research. A summary of the paper follows:

Analysis of primary structure loops from Hairpins 35 and 48 of the Nematoda SSU rRNA gene provides further evidence that the genera *Tripylina* Brzeski, 1963, *Trischistoma* Cobb, 1913 and *Rhabdolaimus* de Man, 1880 are members of Enoplida

Zengqi Zhao, Dongmei Li & Thomas R. Buckley

Introduction The primary structure of the small subunit (SSU) rRNA Hairpin 35 and 48 loops is highly conserved among multicellular animals in general (Rusin *et al.* 2001). Rare nucleotide substitutions were reported in the evolutionarily conserved loops of Hairpin 35 and 48 of the SSU rRNA gene in all the marine Enoplida (Rusin *et al.* 2001, Zhao *et al.* 2010). This study focuses on the nucleotide substitutions in the SSU rRNA Hairpin 35 and 48 regions with the aim of investigating possible molecular synapomorphies among *Trischistoma*, *Tripylina* and *Rhabdolaimus* and other genera from Enoplida.

Methods Details of the nematode sampling, identification, DNA extraction, PCR and sequencing were described in Zhao & Buckley (2009) and Zhao et al. (2012).

Results A comparison of SSU rDNA sequences revealed that a rare nucleotide transition A → G and a transversion G → Y occurred simultaneously in the evolutionarily conserved loops of Hairpins 35 and 48 of the SSU rRNA gene of *Tripylina* Brzeski 1963, *Trischistoma* Cobb 1913 and *Rhabdolaimus* de Man 1880. The same pair of substitutions occurred in all Enoplida analysed but not in other nematodes.

Discussion Analyses of the primary structure of the SSU rRNA gene seem to provide useful tools for nematode systematic studies. The nucleotide transition in the SSU rRNA Hairpin 35 and transversion in the SSU rRNA Hairpin 48 may have potential for use as a universal molecular diagnostic tool and also for design of selective primers and probes.

NEWS FROM BELGIUM

Lea Meagher has an Erasmus Mundus Scholarship to undertake a Master of Science in Nematology at Ghent University in Belgium. She has sent the following report:

I am currently completing my final semester of the European Master of Science in Nematology. Throughout my Masters I have obtained an extensive amount of knowledge, and skills, related to plant parasitic and free living nematodes with regard to agriculture, quarantine, biocontrol and the environment. Therefore this semester I thought it was important to further investigate the role nematodes have as model organisms and how they are being used in different research fields.

Since February I have been back in Ghent at the Ageing Physiology and Molecular Evolution lab conducting work on the molecular pathways involved in axenic dietary restriction (ADR) lifespan extension in *Caenorhabditis elegans*. I am also looking into the relationship between ADR extension and the lifespan extension that is a result of the reduced function of the mitochondria, associated with the mitochondrial unfolded protein response (mtUPR).

However, this semester I was also lucky to again attend the International Symposium of Crop Protection. Amongst the many interesting presentations was one from the Institute for Agricultural and Fisheries Research (ILVO) which outlined how the β -1-4 endoglucanase gene has been found to be suitable for the molecular quantification of the root lesion nematode *Pratylenchus thornei*. It was mentioned that this could be useful for identification and screening purposes, especially considering this nematode causes up to \$50M worth of losses annually in wheat production in Australia.

Another fascinating part of this semester was participating in a Quarantine, Plant Health and Pest Risk Assessment course presented by Sue Hockland, a consultant in the UK for The Food and Environment Research Agency. It was nice to see that the biosecurity measures, and procedures, that are in place in Australia really are very efficient in comparison to much of the world.

The remainder of this semester will be spent writing and presenting my thesis. It's been an amazing two years, but I'm looking forward to moving back to Australia to be nearer to my family and friends. The ultimate conclusion to my extensive study period would be to obtain fulltime employment within Australia where I would be able to use and expand the knowledge that I have gained though out my 2 years of study. Having travelled copiously whilst being overseas I can acknowledge and accept the challenges facing countries to not

only grow enough food crops to feed an ever increasing world population, but to also ensure the quality of existing crops is sustained.

Lea Meagher

NEWS FROM CIMMYT

Cereal Nematology at CIMMYT and the on-going Soil Borne Pathogens Program at The International Maize and Wheat Improvement Center (CIMMYT) – Turkey program

Background Many of you may be aware that Dr Julie M Nicol, who for ten years headed up the Soil Borne Pathogen (SBP) program in Turkey on wheat at CIMMYT with the Turkish Ministry of Agriculture, recently returned to Australia and is now based out of Geelong in Victoria. Before her departure from Turkey, Dr Amer Dababat was recruited to work on this program with her and has subsequently taken over its leadership for CIMMYT. Amer comes out of Bonn University in Germany with a strong background in nematology and has now been working for CIMMYT for 5 years.

Since the inception of the SBP program at CIMMYT, Julie has kept close links with the Australian Cereal Improvement community and has maintained a series of GRDC projects focussing on the SBP complex on wheat (including root lesion nematodes – *Pratylenchus thornei* and *P. neglectus* and the Crown Rot Fungus *Fusarium* spp.). These projects have been principally funded by GRDC and are represented on the CIMMYT and ICARDA Germplasm Exchange (CAIGE).

<http://caigeproject.org.au/index.php/rootdiseaseresistance/>

CIMMYT and partners have also worked extensively on Cereal Cyst Nematode (*Heterodera* spp.), including a number of different species and pathotypes (*H. filipjevi*, *H. latipons* and *H. avenae*).

Further, four Master Class training programs for Soil Borne Pathogens of Wheat in Turkey (two), China and Tunisia <http://www.crawfordfund.org/resources/master-class-reports/were-successfully-conducted>, supported principally by The Australian Crawford Fund and several other donors (including GRDC), CIMMYT in collaboration with Australian pathology experts. At three of these training programs, several Australian PhD students attended and were able to share and network with global scientists working on SBPs.

With partners, CIMMYT has also led and run a successful International Cereal Cyst Nematode Workshop in 2009 in Turkey. A formal proceedings was published from this <http://repository.cimmyt.org/xmlui/discover>. Since this workshop, CIMMYT (in collaboration with partners) has led a Cereal Nematology workshop in conjunction with the European Society of Nematology meetings (Austria- Vienna 2011 and Turkey-Adana – 2012) and one in conjunction with the International Plant Pathology Congress (China-Beijing-2013). Another Cereal Nematology workshop is planned for 2015 in Ankara, Turkey.

The following is a list of relevant, recent publications from Turkey:

1. A. A. Dababat, M. Imren, Gul Erginbas-Orakci, S. Ashrafi, E. Yavuzaslanoglu, H. Toktay, S. R. Pariyar, H. I. Elekcioğlu, A. Morgounov, T. Mekete (2014).

- Reviewing the importance and management strategies of cereal cyst nematodes, *Heterodera* spp., in Turkey. *Euphytica* (submitted)
2. A. A. Dababat, Gül Erginbaş-Orakçı, H. Toktay, M. İmren, B. Akın, H.-J. Braun, S. Dreisigacker, İ. H. Elekcioğlu, A. Morgounov (2014). Resistance of winter wheat to *Heterodera filipjevi* in Turkey. *Turkish Journal of Agriculture Forestry* 38, 180-186.
 3. A. A. Dababat, S. R. Pariyar, J. M. Nicol, G. Erginbas, C. Wartin, M. Klix, N. Bolat, H. J. Brown, & R. A. Sikora (2014). Influence of fungicide seed treatment on the integrated control of *Heterodera filipjevi* on six wheat germplasms with different levels of genetic resistance under controlled conditions. *Nematropica* (In Press).
 4. İmren, M., Toktay, H., Bozbuga, R., Dababat, A., Özkan, H., Elekçioğlu, İ. H. (2013). Determination of resistance against to cereal cyst nematodes, *Heterodera avenae* (Wollenweber, 1924) in some wheat germplasm. *Turkish Journal of Entomology* 37, 229-238.
 5. Toktay, H., İmren, M., Bozbuga, R., Orakçı, G. E., Dababat, A. and Elekçioğlu, H., (2013). Pathotype characterization of the cereal cyst nematode *Heterodera filipjevi* (Madzhidov, 1981) Stelter in Turkey. *Turkish Journal of Entomology* 37, 213-219.
 6. İmren, M., Toktay, H., Bozbuga, R., A. Dababat and Elekçioğlu, H., (2013). Pathotype determination of the cereal cyst nematode, *Heterodera avenae* (Wollenweber, 1924) in the Eastern Mediterranean Region in Turkey. *Turkish Journal of Entomology* 37, 13-19.
 7. F. Toumi, L. Waeyenberge, N. Viaene, A. Dababat, J. M. Nicol, F. Ogonnaya, & M. Moens (2013). Development of a species-specific PCR to detect the cereal cyst nematode, *Heterodera latipons*. *Nematology* 15, 709-717.
 8. F. Toumi, L. Waeyenberge, N. Viaene, A. Dababat, J. M. Nicol, F. Ogonnaya, & M. Moens (2013). Development of two species-specific primer sets to detect the cereal cyst nematodes *Heterodera avenae* and *Heterodera filipjevi*. *European Journal of Plant Pathology* 136, 613–624.
 9. Erginbas-Orakci, G., Dababat, A.A., Morgonouv, A., and Braun, J.H. (2013). The Dryland Crown Rot Disease: Staus of control options. CGIAR SP-IPM, Technical Innovation Brief. No. 19, February 2013.
 10. Toktay, H., İmren, M., Nicol, J. M., Dababat, A and Elekcioğlu, I.H. (2012). Improved methodology for resistance screening in spring wheat against the root lesion nematode, *Pratylenchus thornei* (Sher et Allen, 1953). *Turkish Journal of Entomology* 36, 533-540.
 11. Toktay, H., Yavuzaslanoğlu, E., İmren, M., Nicol, J. M., Elekçioğlu, I. H and Dababat, A. (2012). Screening for resistance to *Heterodera filipjevi* and *Pratylenchus thornei* in sister lines of spring wheat. *Turkish Journal of Entomology* 36, 533-540.
 12. İmren, M., Toktay, H., Özarslandan, A., Dababat, A., Elekçioğlu, I. H., (2012). Effect of temperatures on incubation duration of *Heterodera avenae* cyst and optimization of some materials and methods. *Turkish Journal of Entomology* 36, 585-593.
 13. İmren, M., Waeyenberge L, Viaene N, Toktay, H; A; Dababat A; & Elekçioğlu H. (2012). Molecular characterization of cereal cyst nematodes from South Anatolian Region in Turkey using ITS-rDNA sequences. *Turkish Journal of Entomology* 36, 491-499.
 14. M. İmren, L. Waeyenberge, H. Toktay, A. Dababat, J. M. Nicol, İ. H. Elekcioğlu (2012). Molecular characterization of cereal cyst nematodes from Southeast Anatolia in Turkey using ITS-rDNA sequences. *Türk. entomol. derg.*, ISSN 1010-6960.

Where to from here Since 1998, the SBP-CIMMYT–Turkey program has closely collaborated with the Australian Wheat Community through a project funded by the Grain Research Development Corporation (GRDC). Recently, this was extended for another 5 years (July 2013 – June 2018), to work on the identification and utilization of novel sources of resistance to crown rot and root lesion nematodes in adapted Mexican spring and durum wheat germplasm. Julie will continue to be part of this project as a consultant for GRDC.

A great opportunity for young Australian students As part of this new investment project, we are seeking 2 PhD students who are Australian citizens to work on crown rot and root lesion nematodes respectively. As part of their PhD, the selected students will spend some time in Turkey working collaboratively with CIMMYT at Ankara SBP program.

The PhD student to work on Crown Rot has been selected and will compare growth patterns of three crown rot pathogens in wheat under the major supervision of Prof Mark Sutherland and also Dr Noel Knight (University of Southern Queensland Toowoomba) with CIMMYT.

WE ARE LOOKING FOR A PROMISING YOUNG STUDENT TO BE THE PHD CANDIDATE TO WORK ON ROOT LESION NEMATODES. The proposed study will be the genetic basis of resistance to both *Pratylenchus* spp. (*P. neglectus* and *P. thornei*) in spring and wheat germplasm, under the major supervision of Prof Stephen Neate (University of Southern Queensland/DAFF Toowoomba) with CIMMYT.

A competitive University Scholarship will be sought for each potential PhD student, and top up GRDC funds are anticipated. **PLEASE IF YOU ARE INTERESTED OR KNOW OF ANYONE WHO HAS INTEREST IN THIS CAN YOU KINDLY PASS ON THIS INFORMATION AND ASK THEM TO CONTACT ONE OF US.**

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Thesis Abstract

PRIORITISATION OF PEST SPECIES FOR BIOSECURITY RISK ASSESSMENTS: USING PLANT-PARASITIC NEMATODES AND AUSTRALIA AS EXAMPLES

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Summary of thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy, August, 2013.

Prioritisation of the many potential exotic invasive species is a basic first step in biosecurity screening. This initial step is essential because there are too many species to assess each in detail, and many factors influencing the risks from each. Systematic and transparent methods for prioritisation are required by the World Trade Organization Sanitary & Phytosanitary Agreement (SPS), the overall international governing agreement for biosecurity procedures. Systematic methods are especially important for plant pests because data are often sparse, or variable in quality. Currently, there are no systematic methods for preliminary assessment of risks from plant pests and diseases (as opposed to weeds and animal diseases). This thesis reports studies in developing and testing systematic methods for prioritising the biosecurity risks. Plant-parasitic nematode (PPN) species are used as the exemplar because they have many of the characteristics of both larger insect pests and smaller microbial pathogens, like great diversity, enormous abundance and a wide range of ecological niches, transport pathways and effects on plants. Australia is used as the exemplar geographic location because it is a single political entity which is also well-defined, being an island, and has a wide range of crops and bioclimatic regions.

The biological characteristics, mechanisms for adapting to new environments and pathways for introduction or spread were initially evaluated for all PPN currently regarded as invasive to identify the most important contributors to their invasion potential. Few PPN species are well investigated as invasive species, but several characteristics were identified as common to invasive PPN. These included: adaptations for human mediated dispersal; multiple potential entry pathways; microscopic size; large number of propagules; high fecundity; many or cosmopolitan hosts; short life cycles; ability to survive harsh or unfavourable conditions; ability to vary sex ratios; and ability to overcome host plant resistance. Several major knowledge gaps were identified in assessing invasion potential. These were: lack of information on species biogeography; lag times from arrival to recognition as invasive; interactions among PPN or with other organisms leading to competition, co-existence or persistence; impacts on natural ecosystems; and the role of genetic variability in invasion success. These results are used in the development of a multi-criteria scheme for evaluating biosecurity risks in the third stage of this study (the Pest Screening and Targeting or PeST framework).

Initially, all scientifically named PPN species were reviewed and 250 PPN species from 43 genera were selected for further analysis, based on the explicit criteria of: association with economically important crop hosts; ability to act as vectors of viruses or to form disease complexes with other pathogens; and recognition in phytosanitary regulations of any country in the world. Scientific data on these 250 species was consolidated and is presented as a table, together with additional information on

the crop hosts and yield losses. This comprehensive dataset provides the basic information for the later stages of this study.

The worldwide distributions of the 250 PPN species were ascertained, and then quantitatively modelled using a self-organising map (SOM) to cluster regions with similar species assemblages and rank species based on their likelihoods of establishment in Australia. Australia as a whole was analysed, together with each of states and territories separately, and the risks from the different PPN species varied between jurisdictions according to differences in climates and cropping history. The risks identified were consistent with the known biology and ecology of the species. Altogether 18 countries spanning Asia, Africa, North and Central America, Europe and the Pacific had very similar PPN species assemblages to somewhere in Australia. A total of 97 exotic PPN not currently in Australia had high likelihoods of establishing somewhere in Australia. Some of the species identified as high risk are already on high-priority pest lists for quarantine, but some had not been previously identified as risks. The species identified as risks came from many different countries and parts of the world. These results suggest that further investigation of these species is warranted, using criteria other than species distributions, and this is done in subsequent chapters.

The PeST framework was developed to integrate heterogeneous information and data on species biogeography, biotic and abiotic factors into an overall risk index. The framework is based on expert opinion obtained from a survey of expert nematologists and the criteria they use to identify biosecurity risks, plus the review of the characteristics of invasive nematodes and other organisms presented in chapter 2. The PeST framework evaluates semi-quantitatively information on the host range, pathogenicity, emerging pest status, survival adaptations, pathways, pathotypes, disease complexes, species identification, and uncertainty based on knowledge base of a species. A weighted averaging method is used to combine the scores from the multi-criteria evaluation with the species establishment likelihoods from the SOM analysis. The PeST framework was used to evaluate the 97 PPN species and to rank them based on the overall risk index. Of the ten criteria used in the PeST framework, emerging pest status, pathogenicity, host range and the SOM index (based on species biogeography) most strongly influenced overall risk. The species identified as greatest risks included both new and currently-recognised species. The former included *Heterodera zae*, *Meloidogyne graminicola*, *M. enterolobii*, *M. chitwoodi* and *Scutellonema bradys*, while the latter included *Bursaphelenchus xylophilus*, *Ditylenchus destructor*, *Globodera pallida*, *Heterodera glycines* and *H. filipjevi*. By explicitly evaluating uncertainty, and comparing with the risk index, species where further research to fill in knowledge gaps would be most beneficial were identified.

Three species were chosen for CLIMEX modelling to cross-validate their biosecurity risks to Australia. Two of the species—*Heterodera zae* and *Meloidogyne graminicola*—were the highest risks identified by the PeST framework, and the other—*Hirschmanniella oryzae*—had the highest SOM index but ranked only 20th using the PeST framework. The models were carefully parameterised with species phenology and global distributions obtained from peer reviewed literature. Rain-fed and irrigation scenarios were included to simulate possible different field conditions. The projected species distributions from CLIMEX were concordant with all available experimental and field observations with only a few exceptions. All three species had high eco-climatic and growth index values in Australia (>30), suggesting the biosecurity risks identified by other criteria are real. Maps of host crops (maize, rice, wheat) and irrigation areas in Australia were compared with projected growth index maps of each nematode species to identify areas at risk. Much greater areas were conducive for the growth of the three species under irrigation than under rain-fed conditions, both globally and in Australia. These results show that modified conditions such as irrigation need to be taken into consideration when assessing the establishment potential and biosecurity risks from exotic species.

This study has developed and tested a systematic framework and analytical methods for use on a large number of potential invasive pest species to rank species biosecurity risks to any country or jurisdiction. The process is transparent, open to peer review and explicitly takes into consideration heterogeneous information and uncertainty, when estimating the biosecurity risks from a species. The methods and the process outlined in this study could be used by biosecurity agencies worldwide to complement methods already in use for gathering information and analysing data for future biosecurity risk assessments on both nematodes and other taxonomic groups. In addition, the datasets

on distribution and main hosts of 250 PPN species of potential phytosanitary importance may be valuable for nematologists worldwide in assessing the biosecurity risks from PPN.

Chapters 2, 3, 4, 5 and 6 of this thesis are in the format of scientific papers and have either been published, or are under review for publication under the following titles:

Chapter 2: Singh SK, Hodda M, Ash GJ and Banks NC. 2013. Plant-parasitic nematodes as invasive species: characteristics, uncertainty and biosecurity implications. *Annals of Applied Biology* 163, 323-350.

Chapter 3: Singh SK, Hodda M and Ash GJ. 2013. Plant-parasitic nematodes of potential phytosanitary importance, their main hosts and reported yield losses. *EPPO Bulletin*. 43, 334-374.

Chapter 4: Singh SK, Paini DR, Ash GJ and Hodda M. 2014. Prioritising plant-parasitic nematode species biosecurity risks using self-organising maps. *Biological Invasions* 16, 1515-1530.

Chapter 5: Singh SK, Ash GJ and Hodda M. 2013. Keeping one step ahead of invasive species: Using an integrated framework to screen and target species, for detailed biosecurity risk assessment. Manuscript is under peer review in *Journal of Applied Ecology*.

Chapter 6: Singh SK, Kriticos DJ, Ash, GJ and Hodda M. 2013. Cross-validation of biosecurity risks from plant-parasitic nematodes to Australia using CLIMEX modelling. Manuscript is in preparation for *Australasian Plant Pathology*.