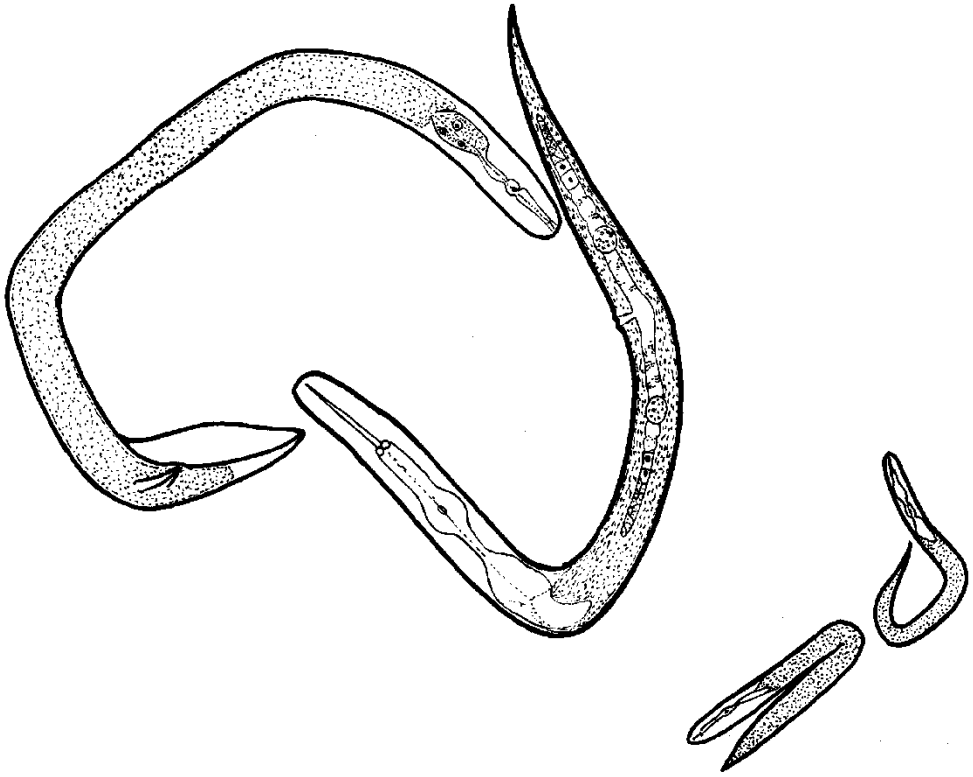
ISSN 2208-4312

AUSTRALASIAN NEMATOLOGY NEWSLETTER



Published by: **Australasian Association of Nematologists**

VOLUME 30 NO. 2 **JULY 2019**

From the Editor

Thank you to all contributors for sharing your latest news and research outcomes in this issue of the Newsletter.

Articles on regional news, recent publications, announcements of new research projects, colleagues, visitors, students etc., research reports, conference or workshop reports, abstracts of recently submitted/accepted PhD theses, conference or workshop announcements and photos are welcome for publication in the AAN Newsletter. Contributions will be accepted at any time throughout the year so please forward articles and reports to me as they occur, with the deadline for the next issue in December 2019.

I look forward to receiving your contributions for future issues and keeping you up to date with the regional news of our AAN members.

Rebecca Zwart

Contacts

Dr Mike Hodda
President, Australasian Association of Nematologists
CSIRO Ecosystem Science — Tel: (02) 6246 4371
GPO Box 1700 — Fax: (02) 6246 4000
Canberra ACT 2601 — Email: mike.hodda@csiro.au

Dr Sarah Collins
Secretary, Australasian Association of Nematologists
Department of Agriculture and Food — Tel: (08) 9368 3333
Locked bag 4 — Fax: (08) 9474 2840
Bentley Delivery Centre WA 6983 — Email: sarah.collins@agric.wa.gov.au

Dr Kathrine Linsell
Joint Treasurer, Australasian Association of Nematologists
SARDI Plant Health and Biosecurity — Tel: (08) 8303 9437
Plant Research Centre, Hartley Grove — Fax: (08) 8303 9393
Urrbrae SA 5064 — Email: katherine.linsell@sa.gov.au

Ms Sue Pederick
Joint Treasurer, Australasian Association of Nematologists
SARDI Plant Health and Biosecurity — Tel: (08) 8303 9585
Plant Research Centre, Hartley Grove — Fax: (08) 8303 9393
Urrbrae SA 5064 — Email: sue.pederick@sa.gov.au

Dr Rebecca Zwart
Editor, Australasian Nematology Newsletter
Centre for Crop Health — Tel: (07) 4631 1544
University of Southern Queensland
Toowoomba QLD 4350 — Email: rebecca.zwart@usq.edu.au

Association News

FROM THE PRESIDENT

A somewhat longer note than last time having actually spent the last few months in the office. So what do I think you need to know about what is going on in nematology?

The 7th International Congress of Nematology is on from 3rd – 8th May 2020. I am a big supporter of these meetings as a way of learning what is going on elsewhere in the world, and forming contacts for when needed. I suppose this is especially important in biosecurity where I do a lot of work, because we are dealing with exotic nematodes that people in other countries deal with all the time, but we seldom see because—fortunately for us—they are not here yet. But as many of our current pests are exotics, developments elsewhere in the world are relevant to most plant-parasitic nematode issues here. The conference is in the major hardship destination of Antibes, southern France, so I have booked my air fare and accommodation already. If you get in quick, there are some quite reasonable options because only the more expensive options may be available closer to the date. Contact me as the AAN representative to the organizing committee, or else check out the web site.

If you are a student and a member of AAN, and you would like assistance to attend the ICN, remember that the Australian Nematology Support Fund offers substantial sponsorship. The application procedure is as simple as sending a few paragraphs of who you are and why you want to go. The selection committee is the AAN executive, so we normally have a response pretty quickly. I cannot recall anyone being knocked back, although I'm not sure everyone received everything they wanted: the fund can seldom give full funding, but it can be really useful leverage for other funding sources, and seeking out extra funding is really good training for a student. Contact me or any other member of the executive with any queries. The ICN should be the only major nematology conference next year, but if there are any other worthwhile events relevant to nematology in Australia or elsewhere that you want to go to, sponsorship is possible for these, too.

The call for expressions of interest in attending the Nematodes in Cropping Systems Workshop is included on pages 15 - 19 in the newsletter. The dates and venue are 2nd - 6th December 2019 at The University of Adelaide. This year we have Dorota Porazinska from The University of Florida helping us out, and as a result, there will be more emphasis on molecular approaches and metagenetics. Contact me or Kerrie Davies as soon as you can if you might be interested. I know I have written for previous courses that they might be Kerrie's last, but as you can judge from her other contributions for the newsletter, Kerrie might actually be serious about it this time.

As a result of Kerrie getting serious about retirement, we are in the process of incorporating the Waite Institute Nematode Collection into the ANIC Nematode Collection, which is a cue to write about vouchering. Vouchering is an important way to verify what is found and used in experiments, and is essential under the International Plant Protection Convention. And we in Australia do not do enough of it, like most of the world. So there is likely to be a push for an increase in the next Plant Biosecurity Strategy, which is due next year.

Seeing Kerrie's piece on *Steinernema* in this newsletter has prompted me to write about perfection in descriptions. (Where will we be without Kerrie's very active role in nematology in Australia?) I think it is a real shame that the descriptions are not publishable in the mainstream literature because they are regarded as incomplete. How much nematode material is out there which is incomplete because there are

no males, no adult females, too few specimens, etc.? And all this material and information is inaccessible because it never sees the light of day. While it is better to know that *Meloidogyne javanica* occurs in large numbers on a particular crop in a particular area, it is still valuable to know that a species of *Meloidogyne* occurs on the crop, even if we are not sure which one. And if there is voucher material—both morphological specimens and genetic material—we can go back and work out which species it was later if it turns out to be important. Although amazingly common with nematodes, this sort of situation also occurs with other organisms.

Mike Hodda

FROM THE TREASURERS

Fees for the AAN (Australasian Association of Nematologists) are due annually 1st July through to 30th June. The $15 annual fee covers newsletter articles and information regarding nematology opportunities including specialised workshops.

If you are outstanding with your fees you will be contacted shortly for the previous year.

You can no longer pay through the APPS web site when registering your membership, all now come through the AAN bank account. We have had support for many years with APPS but they are no longer able to assist with this service due to logistics.

ONLY Payment Method

ANZ

Account Name: Australasian Association of Nematologists

BSB: 012-950

Account # 5180-07506

Looking forward to your continued support and the camaraderie the Nematology group brings.

Kind Regards

Katherine Linsell and Sue Pederick (Joint Treasurers AAN)

Regional News

NEWS FROM QUEENSLAND

Sugar Research Australia (SRA)

Dr Shamsul Bhuiyan attended the 11th International Congress of Plant Pathology (ICPP2018) was held at the US city of Boston, Massachusetts from 29th July to 3rd August 2018. The theme of the congress was 'Plant Health in a Global Economy', and it attracted one of the largest congregation of Plant Pathologists and Plant Scientists from across the globe. More than 2,400 scientists from 88 countries were attended to the congress. Nearly 500 oral presentations in 75 concurrent sessions, five plenary and 15 keynote presentations and 1,200 posters make this congress one of the largest scientific conference in agricultural science.

The SRA was represented by Dr Bhuiyan, Dr Rob Magarey and Dr Jaya Basnayake. Dr Bhuiyan presented one oral presentation and co-chaired a session. Dr Magarey, who is the Councillor of the International Society of Plant Pathology (ISPP), also presented at the congress.

Dr Bhuiyan with SRA scientists Drs Rob Magarey (left photo) and Jaya Basnayake (right photo) at the ICPP poster viewing hall.

Publications:

Bhuiyan, S.A., Croft, B.J., Cox, M., & Jackson, P. (2018) Novel source of nematode resistance for Australian sugar industry. Paper presented at the International Congress of Plant Pathology, Resistance to Nematodes Session, Boston, USA. https://apsnet.confex.com/apsnet/ICPP2018/meetingapp.cgi/Paper/9809

Bhuiyan, S.A., Garlick, K., and Piperidis, G. (2019). *Saccharum spontaneum* – novel source of resistance to root-lesion and root-knot nematodes in sugarcane. *Plant Disease*. doi:10.1094/PDIS-02-19-0385-RE

Bhuiyan, S.A., Piperidis, G., Hu, F., Parfitt, R., Garlick, K., Quinn, B., & Jakins, A. (2019) Field evaluation of selected introgression clones for their resistance to root-knot nematodes. Proceedings of the Australian Society of Sugarcane Technologists 41.

Ramouthar, P.V., and Bhuiyan S.A. (2018) Nematode parasite of sugarcane. In: R.A. Sikora, M. Luc, J. Bridge (Eds), *Nematodes in subtropical and tropical agriculture*. CAB International: Wallingford, UK.

University of Southern Queensland

Planting field and glasshouse experiments are in full swing by the Crop Nematology team at University of Southern Queensland (USQ).

The Grains Research and Development Corporation (GRDC)-funded 'National Nematology Epidemiology and Management project' (DAV00128) will be completed in June 2019. The Queensland component (led by Kirsty Owen) of this project produced some new results on the tolerance and resistance to *Pratylenchus thornei* of important northern region crops including cultivars of mungbean, chickpea, faba beans maize and wheat. A new GRDC-funded project will begin in July 2019 and Kirsty and her team will investigate 1) the interaction of *P. thornei* and crown rot (*Fusarium* spp.), 2) *P. thornei* and arbuscular mycorrhizal fungi and 3) *P. thornei* and rates of nitrogen fertiliser on the growth of wheat cultivars in the field.

PhD student Sonal Channale is currently on a 3 month visit to the International Crops Research Institute of the Semi-Arid Topics (ICRISAT) in Hyderabad India, as a recipient of a Crawford-In-Qld Student Award. Sonal will conduct a component of her thesis project on identification of candidate resistance genes in chickpea (*Cicer arietinum*) against root-lesion nematode (*Pratylenchus thornei*). Hannah Rostad, a member of the USQ Crop Nematology team since 2015, has taken on the challenge of a higher degree by research by enrolling in a Master of Science commencing in semester 2 this year. Hannah's project is titled "Resistance of wild relatives (*Cicer reticulatum* and *C. echinospermum*) of chickpea (*C. arietinum*) to the root-lesion nematode *Pratylenchus neglectus*".

Publications:

Robinson, N.A., Sheedy, J.G., MacDonald, B.J., Owen, K.J., & Thompson, J.P. (2019) Tolerance of wheat cultivars to root-lesion nematode (*Pratylenchus thornei*) assessed by normalised difference vegetation index is predictive of grain yield. *Annals of Applied Biology*, *174*, 388-401. doi: 10.1111/aab.12504

Reen, R.A., Mumford, M.H., & Thompson, J.P. (2019) Novel sources of resistance to root-lesion nematode (*Pratylenchus thornei*) in a new collection of wild *Cicer* species (*C. reticulatum* and *C. echinospermum*) to improve resistance in cultivated chickpea. *Phytopathology*. 109, 1270-1279. doi: 10.1094/PHYTO-02-19-0047-R

Kirsty Owen and Rebecca Zwart

NEWS FROM SOUTH AUSTRALIA

The University of Adelaide

Kerrie Davies is finalising the curation of the Waite Nematode Collection, and it is being packed up for transfer to Mike Hodda at ANIC, CSIRO Ecosystem Sciences, Canberra. So many loose ends. Kerrie and 'Fred' Bartholomaeus have been working on this now for about 15 months.

Kerrie is also finalising reports and manuscripts. One of these, on *Steinernema*, appears in this issue (see page 7) – only roughly 20 years late! She will finish work on 31st December, and leave the Waite, with which she has been associated for about 50 years.

Kerrie hopes that enough people will enrol in the proposed Short Course in Plant and Soil Nematology, to be held in Adelaide in early December, to enable it to go ahead. It would be a great way for her to go 'out'. See page 15 for details of the Course.

Ian Riley will be back in Adelaide from Turkey for about 6 weeks, from late June. He is teaching Soil Biology at Niğde Ömer Halisdemir Üniversitesi, Niğde, Central Anatolia.

Kerrie Davies

NEWS FROM VICTORIA

Horsham

A wet start to the 2019 winter has been most welcome, with the last of our trials sown in June. With the National Nematology project coming to an end, and final reports currently being prepared, we have started some exciting new research into soilborne disease interactions. This is taking a national approach with trials, and in Victoria we are focussing on *Pratylenchus thornei* and *P. neglectus* in combination with other pathogens, including *Fusarium pseudograminearum* and *Rhizoctonia solani* and how these combinations impact grain yield. We are also investigating how higher rainfall will impact grain yield and multiplication of *P. thornei*, and the impact of nitrogen on *P. neglectus* multiplication and the grain yield losses they cause.

In addition to this new research, we are continuing to look at pulse resistance in the presence of *P. neglectus* and *P. thornei*, now including vetch in our mixed crop trials with lentils, field peas, faba beans and chickpeas. We are also investigating oat resistance to *P. thornei* and cereal resistance to cereal cyst nematode.

In April 2019 Mark J. Blacket, et al. published work on Potato Cyst Nematode (PCN) in Phytopathology (see reference below). They used a microsatellite approach to genotyping PCN larvae, which clearly demonstrated that Victoria had only a single introduction of PCN with limited spread, implying that the biosecurity restrictions put in place were very effective. It was selected by Phytopathology's editor as article of the month.

Publications:

Blacket, M.J., Agarwal, A., Wainer, J., Triska, M.D., Renton, M. & Edwards, J. (2019) Molecular assessment of the introduction and spread of potato cyst nematode, *Globodera rostochiensis*, in Victoria, Australia. *Phytopathology, 109:4*, 659-669. doi: 10.1094/PHYTO-06-18-0206-R

Jonathan Baker, Joshua Fanning and John Wainer

Research Report

SOME OBSERVATIONS ON *STEINERNEMA* IN AUSTRALIA

***Kerrie Davies**, School of Agiculture, Food and Wine, University of Adelaide*
***Janine Paynter** (nee Lloyd), Aucland, New Zealand*

Steinernema nematodes carry the symbiotic bacterium *Xenorhabdus*, and release it when their infective juveniles invade a host insect. The bacterium then kills the insect, and the nematodes feed and develop on the multiplying bacteria. Several species of *Steinernema* are used commercially as biocontrol agents of pest insects, and there is considerable potential for many more to be used in this way. The genus is speciose (http://entnem.ifas.ufl.edu/nguyen/morph/steinsp1.htm) with more than 60 recognised species, and phylogenetic analyses show that it contains 5 clades or groups of species (Spiridonov *et al*., *Nematology*, 2004, Vol. 6, 547-66).

The Waite Insect and Nematode Collection (WINC) includes a large collection of *Steinernema* nematodes from Australia, developed via funding by a grant from the Australian Biological Resources Survey (ABRS) to Kerrie Davies in 1992–1994 on 'Potential biological control agents: Distribution and taxonomy of entomophilic nematodes'. As part of this work, Janine Paynter (nee Lloyd) collected three putative new and two known species of *Steinernema*, and most isolates were cultured to obtain enough material for cross-breeding experiments, processing, drawing and measuring. A manuscript describing the new species was produced in 1995. However, the work was submitted for publication about the same time that an international workshop was held at which minimum standards were set for future descriptions of new species of the economically important genus *Steinernema* (published Hominick *et al*., 1997, *J. of Helminthology*, vol. 71, pp. 271-298). Valid descriptions of all new species of the economically important genus must now have morphological, cross-breeding and molecular data. Because our work lacked the latter, the descriptions were not accepted. By then, the grant had ended, the cultures were not kept, and we had not prepared frozen samples. Take note, fellow nematologists, and learn.

Given the economic importance of *Steinernema*, we have decided to send the information we have to the AAN newsletter, so that at least information on the distribution and morphology of the forms we collected will be available for future work on these potential biocontrol agents.

Distribution

An opportunistic survey of Australian soils, using *Galleria* traps, from the Northern Territory, New South Wales, South Australia and Western Australia yielded various species of *Steinernema*, including three putative new species. Two hundred sites were sampled, and *Steinernema* was found at 38 of these. The sites ranged from the Northern Territory (monsoonal), to QLD (tropical), the south-west corner of WA and southern SA (cool temperate), and the semi-desert areas of SA, i.e., it appears that the genus is widespread throughout Australia. *Heterorhabditis bacteriophora* was found at two sites (Table 1), both from cooler areas of SA. Since this survey was carried out, *Heterorhabditis* has also been collected from Darwin (Sagun *et al*. (2015) *Zootaxa* 4040, 17-30).

Cross-breeding

Cross-breeding experiments (Akhurst & Bedding, *Nematologica* 1978, p. 328) were used to determine which isolates could interbreed. Isolates with similar morphologies from different samples were crossed to determine if they could interbreed, and/or were crossed with known species. Test and control crosses were repeated twenty times for each isolate. Results of the cross-breeding experiments correlated with the

morphological studies of the specific isolates (Tables 2, 3). Morphospecies B was only available as fixed material, so could not be tested. Morphospecies A is morphologically closest to *S. kushidai*, which was not available for cross-breeding work, and was so morphologically distinct from other *Steinernema* collected in the survey that cross-breeding with it was not attempted.

Table 1. Distribution of *Heterorhabditis* and *Steinernema* collected from Australian soils 1992-95.

Isolates	Collection sites
Heterorhabditis (WNC 594, 662)	Meningie, Mt. Gambier (SA)
S. feltiae (WNC 684, 666, 346)	Forest Range, Mt Gambier (SA); Marlo (Vic)
S. glaseri (WNC 669)	Mt Gambier, Penola (SA)
Steinernema Morphospecies A (WNC 488)	Fitzgerald Nat. Park (WA)
Steinernema Morphospecies B (WNC 925)	Darwin (NT)
Steinernema Morphospecies C (WNC 664, 598, 499, 569,570,571,573,547, 508, 583,516, 536)	Mt Gambier, Whyalla (SA); Brockman Highway, East Margaret River, Hassell Nat. Park, Leuwin-Naturaliste Nat. Park, Manjimup, South West, Tuart Forest Nat. Park, Walpole Nat. Park, Yannup State Forest (WA)
Steinernema spp. (WNC 307, 196, 1025, 594, 640, 34, 723, 499,571, 554, 563, 540, 554, 532, 544, 504, 508, 527)	Mt Boss State Forest (NSW); Mossman R. Nat. Park (QLD); Spalding, Meningie, Nangkita, Telowie Gorge (SA); Jabiru, Hassell Nat. Park, Leuewin-Naturaliste Nat Park, Manjimup, Margaret River, Nannup, Pemberton, Quinninup, Stirling Ranges, Valley of the Giants State Forest (WA)

WNC = Waite Nematode Collection

Table 2. Cross-breeding of selected isolates of *Steinernema* with previously described species.

	MSp C 583	MSp A 488	MSp C 516	*S. feltiae*	*S. carpocapsae*
S. carpocapsae	NA	NS	NS	NA	+
S. feltiae	NS	NA	NA	+	
MSp C 516	NA	NS	+		
MSp A 488	NA	+			
MSp 583	+				

NA = cross was not attempted or it was and the control also failed; NS = strains did not cross breed but both controls were successful; + = Controls and test produced offspring.

Morphology and morphometrics of morphospecies

MSp A (Table 3, Fig. 1)

Isolate 488; collected from WA (33˚ 40'S; 119˚ 20'E).

Infective juvenile relatively small ca 470-540 µm long; head rounded, mouth closed; lateral field with 8 ridges; amphid opening narrow, crescent-shaped, situated below lateral lips; excretory pore at 40-60% length of the oesophagus; intestinal vesicle short and spherical; phasmids not apparent; tail tapering to a point, may be asymmetrical.

First generation male C or J-shaped when relaxed; anterior end with 6 lip papillae and 4 cephalic papillae, stoma shallow; oesophagus muscular with vestigial median bulb, terminal bulb with reduced valve; ovoid cardia; intestine lined with large cells with distinct nuclei; spicules paired, arcuate, yellow colour, manubrium of spicule tapered anteriorly, ribs of lamina converging at manubrium, small rostrum and velum present, lamina pointing to pointed tip; gubernaculum 60-70% length of spicule; 6 pairs of sub-ventral papillae and a single large pre-anal papilla; bluntly rounded tail with 2 lateral, 1 adanal, and 2 subterminal pairs of papillae.

First generation female C-shaped or coiled, very variable in length; stoma shallow; position of excretory pore variable at 25-70% length of oesophagus; tail conical; large rectal glands surrounding anterior half of rectum.

Second generation male smaller than first. Second generation female with 3 rectal glands, tail with post-anal swelling.

Juveniles characterised by short spherical vesicle; males by having yellow spicules; G1 males with relatively long testes, G1 females by having large glands associated with the rectum. Close to *S. kushidai*.

Table 3. Measurements and morphometrics of *Steinernema* MSp A . All measurements are in µm (range).

Character/ratio	G1 males N = 20	G1 females N = 20	G2 males N = 10	G2 females N = 10	Infective J3 N= 20
Body Length (L)	1003-1560	2000-10,100	640-844	920-1640	471-537
Greatest width	83-130	118-277	44-59	53-100	19-28
Stoma Length	3-7	8-34	-	3-7.5	-
Stoma width	4-8	10-20	-	4-7.5	-
Length vesicle					5.5-7
Ant. end to excretory pore	56-76	42-212	28-49	40-70	37-51
Ant. end to nerve ring	84-117	88-274	73-88	83-118	59-68
Length pharynx (ES)	95-114	160-323	108-129	133-174	86-102
Testis reflexion	726-1410		310-455		
Tail Length	18-35	14-55	47-71	25-42	41-57
Anal body width (AB)	31-43	42-122	18-25	17-35	-
Spicule length (SL)	55-71		36-48		
Manubrium width	8-11		6-8.5		
Gubernaculum length (GL)	38-52		24-31		
Gubernaculum width	5-8		4-7		
Ant. end to vulva		800-6000		472-880	
V%		31-60		54-61	
Ratio a (L/W)	-	-	-	-	18-27
Ratio b (L/ES)	-	-	-	-	4.4-5.8
Ratio c (L/tail)	-	-	-	-	9-12
SW (SL/AB)	1.5-2.0		1.4-2.3		
GS (GS/SL)	0.6-0.87		0.6-0.7		
D (EP/ES)	40-63	25-73	22-39	20-40	39-56
EP/Tail	178-364	116-638	47-80	104-172	73-126

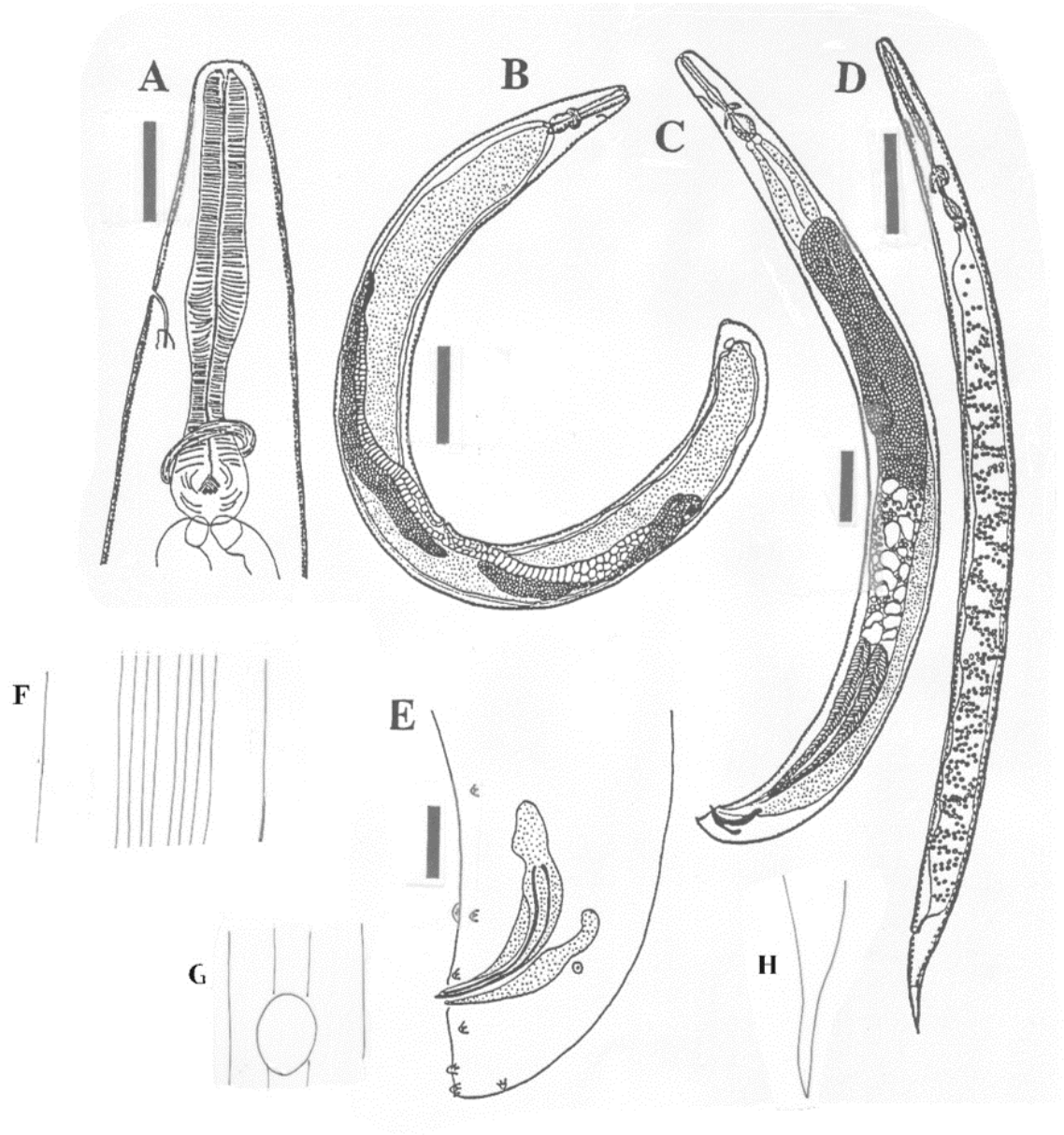


Fig. 1. *Steinernema* morphospecies A. All drawings in lateral view. A: Anterior end of G1 female; B: whole body of G1 female; C: Whole body of G1 male; D: Whole body of infective juvenile; E: Tail of G1 male; F. Lateral lines (schematic); G: Lateral vesicle showing oval shape (schematic); H: tail of infective juvenile (schematic). (Scale bars: A, D = 40 µm; B = 200 µm; C = 100 µm; E = 20 µm.)

MSp B (Table 4, Fig. 2)

Isolate WNC 925; collected from Wildman River Cashew Farm, Northern Territory, by R. Bedding. *Ca* 12˚ 18'S; 132˚ 02'E.

Juveniles small, *ca* 540 µm long; straight or slightly curved when relaxed; mouth and stoma closed; prominent amphids; excretory pore 30-40% of oesophagus length; lateral field with 6 ridges with outer ridges most prominent; intestinal vesicle lanceolate, variable in size; tail tapering to pointed tip.

First generation male C-shaped; shallow stoma; prominent amphids; excretory pore at 25-40% length of oesophagus; testis with double flexure; spicules with knob-like offset manubrium, blade tapering, rostrum

and velum present; pre-anal region with 6 pairs of sub-ventral and one large pre-anal papilla; tail with 6 pairs papillae (1 pair sub-ventral and post-anal, 2 lateral, and 2 on tail tip), tail conical with mucron.

First generation female C-shaped or coiled; prominent amphids; excretory pore at 20-50% length of oesophagus with prominent looped duct; conical tail with mucron.

Second generation female with asymmetric stoma.

Juveniles characterised by their small size and relatively anterior excretory pore; males by short double-flexured testis and spicule with knob-like manubrium; and females by large distinct amphids. All stages have strongly sclerotised cheilorhabdions.

Table 4. Measurements and morphometrics of *Steinernema* MSp B. All measurements are in µm (range).

Character/ratio	G1 males N = 20	G1 females N = 20	G2 males N = 10	G2 females N = 10	Infective J3 N = 20
Body Length (L)	928-1328	3000-10000	821-937	1027-1470	492-585
Greatest width	68-100	125-275	44-56	53-77	22-28
Stoma Length	3-4	3-6	3-4	3-4	-
Stoma width	4-7	8-17	3-4	4-7	-
Length vesicle					19-28
Ant. end to excretory pore	36-49	53-84	35-42	34-52	27-34
Ant. end to nerve ring	92-121	106-147	82-94	85-102	57-71
Length pharynx (ES)	126-148	163-232	123-129	123-134	88-108
Testis reflexion	555-708		462-588		
Tail Length	22-33	25-45	15-24	31-43	43-73
Anal body width (AB)	28-36	42-67	22-28	21-25	
Spicule length (SL)	50-65		45-53		
Manubrium width	9-14		7-10		
Gubernaculum length (GL)	32-46		32-39		
Gubernaculum width	5-8		4-6		
Ant. end to vulva		1500-5106		608-856	
V%		37-56		58-60	
Ratio a (L/W)	-	-	-	-	19-25
Ratio b (L/ES)					4.8-6.5
Ratio c (L/tail)					7-11
SW (SL/AB)	1.3-2.0		0.7-1.0		
GS (GS/SL)	1.7-2.4		0.7-0.8		
D% (EP/ES)	28-39	26-46	28-33	26-41	31-38
EP/Tail	145-219	150-322	200-272	92-163	45-69

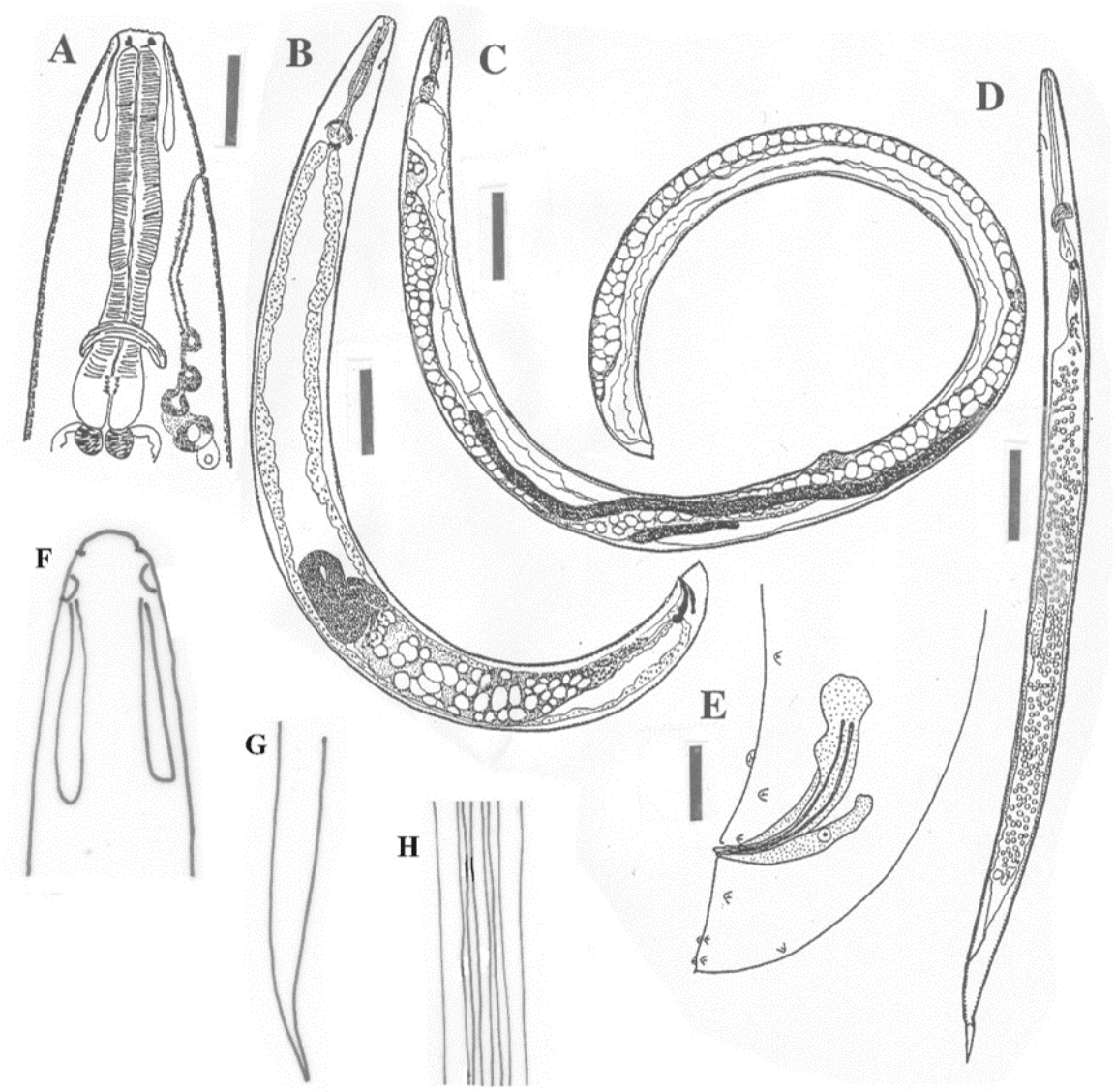


Fig. 2. *Steinernema* morphospecies B**.** All drawings in lateral view. A: Anterior end of G1 female; B: Whole body of G1 male; C: Whole body of G1 female; D: Whole body of infective juvenile; E: Tail of G1 male; F: Anterior end of infective juvenile showing amphids (schematic); G: Tail of infective juvenile (schematic); H: Lateral lines (schematic). (Scale bars: A, D = 40 µm; B = 100 µm; C = 200 µm; E = 20 µm.)

MSp C (Table 5, Fig. 3)

Isolates (WNC numbers) 664, 598, 559 562, 499, 569, 570, 571, 573, 547, 508, 583, 516, 536; collected from SA and WA.

Juveniles *ca* 800 µm long, anterior end truncate; mouth and soma closed; amphid openings slit-like; lateral field with 8 ridges; excretory pore at 40-60% of oesophagus length; intestinal vesicle lanceolate; prominent phasmids midway between anus and tail tip; tail tapering evenly to a narrow, pointed tip.

First generation male with J-shaped body; stoma with ventral tooth; cardia cylindrical, testis reflexed, occupying much of body cavity; spicules arcuate, manubrium variable in shape, lacking rostrum; gubernaculum 80-90% of spicule length; pre-anal region with 5 or 6 pairs of sub-ventral

papillae and a one large pre-anal papilla; tail conoid with 5 pairs of papillae (2 lateral, 1 adanal, 2 sub-terminal).

First generation female C-shaped to coiled; vulval lips with double flapped epiptygma; tail short, broad at anus, rounded tip with mucron.

Second generation female – vulval lips have no epiptygmata; tail slightly longer and narrower than that of G1 female.

Juveniles characterised by intermediate size relative to other species, position of excretory pore, and prominent phasmids; males by having a long gubernaculum relative to spicule length; G1 males by having very large testis relative to body size; and G1 females with a double flapped epiptygmata.

Table 5. Measurements and morphometrics of *Steinernema* MSp C. All measurements are in µm (range).

Character/ratio	G1 males N= 20	G1 females N= 20	G2 males N= 10	G2 females N= 10	Infective J3 N= 20
Body Length (L)	1433-2136	1800-3000	673-1622	747-1829	500-1031
Greatest width	89-148	124-381	44-94	37-100	19-37
Stoma Length	1-6	4-35	3-4	2-5.5	-
Stoma width	4-8	4-15	2-5.5	4-7	-
Length vesicle					15-75
Ant. end to excretory pore	74-99	30-60	46-91	52-80	41-64
Ant. end to nerve ring	90-122	91-224	77-112	78-132	60-101
Length pharynx (ES)	131-174	116-270	110-139	112-174	90-134
Testis reflexion	870-1440	-	377-716	-	-
Tail Length	28-42	8-48	14-40	28-38	50-83
Anal body width (AB)	36-55	18-60	22-38	18-35	-
Spicule length (SL)	66-80		34-59		
Manubrium width	13-17		7-11		
Gubernaculum length (GL)	49-76		28-44		
Gubernaculum width	8-11		4-7		
Ant. end to vulva		702-2945		418-1074	
V%		38-78		52-59	
Ratio a (L/W)	-	-	-	-	20-40
Ratio b (L/ES)	-	-	-	-	5-9
Ratio c (L/tail)	-	-	-	-	10-15
SW (SL/AB)	1.4-1.9		1.3-2.3		
GS (GS/SL)	0.7-1.0		0.5-0.9		
D(EP/ES)	180-296	81-600	114-274	160-260	66-100

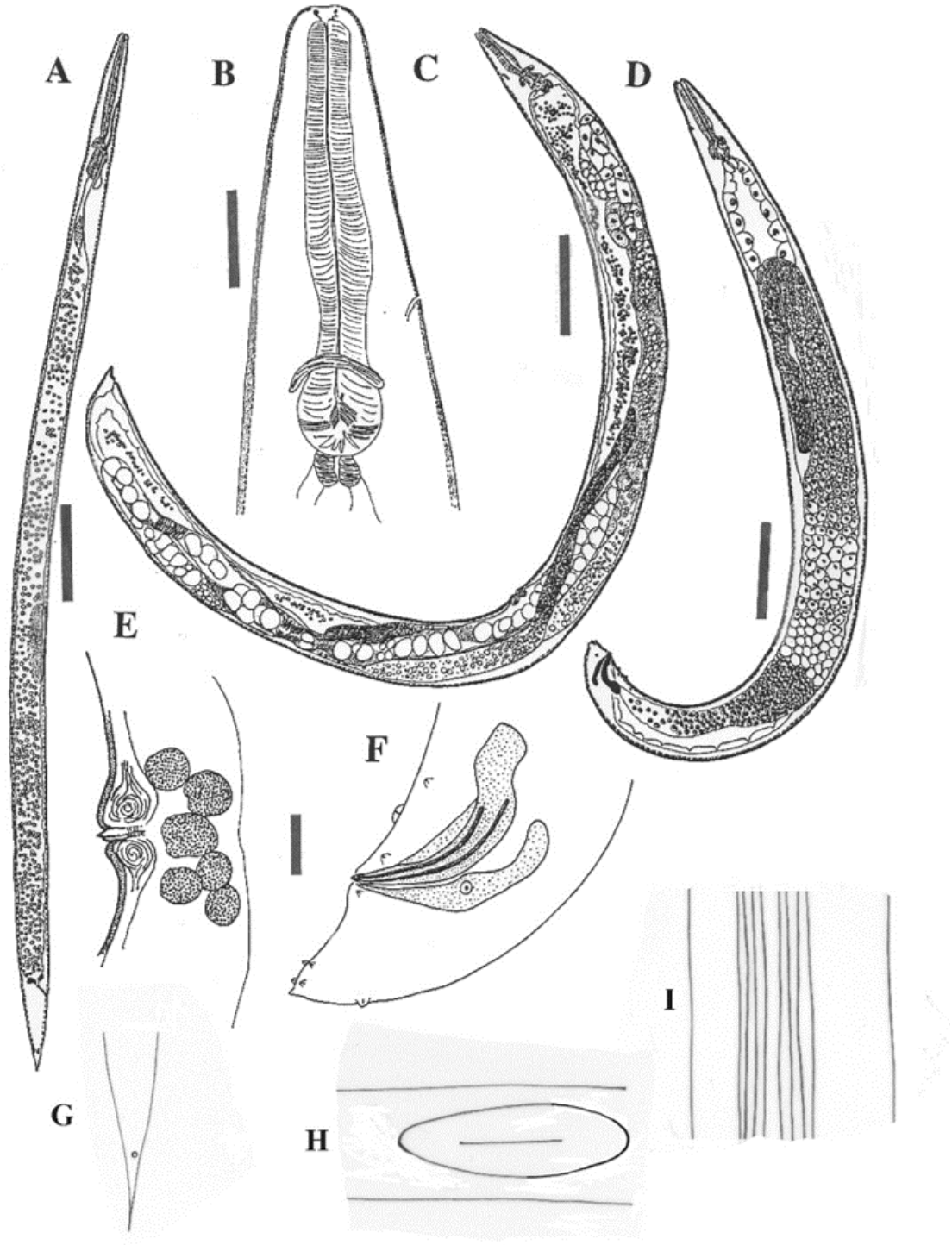


Fig. 3. *Steinernema* morphospecies C. All drawings in lateral view. A: Whole body of infective juvenile. B: Anterior end of G1 female. C: Whole body of G1 female. D: Whole body of G1 male. E: Vulva of G1 female. F: Tail of G1 male. G: Tail of infective juvenile showing phasmid (schematic). H: Lateral vesicle showing lanceolate shape (schematic). I: Lateral lines (schematic). (Scale bars: A = 80 µm; B = 40 µm; C = 200 µm; D = 150 µm; E, F = 20 µm.)

Short Course 2019

NEMATODES IN CROPPING SYSTEMS: IDENTIFICATION & TECHNIQUES 2019

This document is to give information on the course currently scheduled for:

University of Adelaide, 2nd to 6th December 2019.

A draft timetable for the course is below. The content and particular nematodes discussed in the various sessions will be varied to suit the expressed interests of participants. Participants are encouraged to bring specimens or material (subject to local quarantine restrictions) for study and discussion during the course.

The presenters will be:

Dr Mike Hodda, CSIRO
Dr Kerrie Davies, University of Adelaide
Dr Dorota Porazinska, University of Florida

The cost of the course is AUD2000 (excluding GST) or AUD2200 (including GST).

The course costs cover all materials (microscope slides etc), plus a manual, and morning and afternoon teas, but not breakfast, lunch or dinner, accommodation or meals. Some local transport MAY be available by arrangement with local participants. International participants can be met at the airport if desired.

The workshop requires 9 participants to proceed. Please send expressions of interest as soon as possible, and definitely before the end of September 2019.

For further enquiries or to book a place, please email the course coordinator: mike.hodda@csiro.au

Once confirmed, payment details will be forwarded. Payment can be by Credit card or invoice, but will be required prior to the course commencement.

No particular accommodation is suggested or recommended, but there are a number of hotels of various standards available nearby. A list will be sent closer to the course.

Why Nematodes?

Nematodes are the most numerous multi-celled organisms on earth. Soil nematodes are of great importance to cropping systems: they can significantly reduce plant yields; they are biocontrol agents of invertebrate pests; and they recycle soil nutrients. Recent work suggests that they have potential as bio-indicators of soil health. They are frequently encountered in quarantine work.

Specialised knowledge is required to handle and identify nematodes. This course provides the skills and information needed to confidently handle nematodes in a wide variety of situations. It includes sampling, collecting and preparing nematodes for identification, using keys and other tools for identification, as well as the background information needed to deal with nematodes. For the first time, molecular methods will be covered in some detail.

Is this Course for you?

The workshop suits researchers and professionals working in agriculture, quarantine, green keeping, and soil biology, who need to understand the principles and practice of handling soil, plant and insect nematodes. It will provide hands-on experience in sampling, extraction, specimen preparation, culturing, diagnosis, and identification. There will be opportunity for interaction with experts in the field. Participants should have a degree which includes biology, agriculture, or soil science or have appropriate work experience to undertake the workshop. Less experienced participants can be supplied with recommended reading material prior to the workshop.

Course Location

This course is being held in Adelaide, close to the southern grain region, grape-growing areas, and vegetable production. Nematodes from other crops and places in Australia, New Zealand and elsewhere will be treated during the course, but through fixed material. There are direct flights to Adelaide from most Australian capital cities.

Course Presenters

The workshop will be conducted by:

Dr. Mike Hodda (National Research Collections Australia & Biosecurity Flagship, CSIRO, Canberra),

Dr. Kerrie Davies (School of Agriculture, Food & Wine, The University of Adelaide), and

Dr. Dorota Porazinska (Institute of Food & Agricultural Sciences, University of Florida).

The presenters have almost 100 years experience researching nematodes between them, have described numerous species, have research experience in the entire field from pure science to practical applications. They have many years teaching experience to both graduates and undergraduates, and together have studied most taxonomic groups of nematodes over much of the Australia-Asia-Pacific Region, the USA, Europe and Africa.

Course Content

- Sampling and extraction
- Preparation of specimens
- Microscopic techniques
- Ecology and physiology of nematodes
- Identification of free-living, plant parasitic and entomophilic nematodes
- Molecular methods
- Management & Control
- Culturing (if requested)

Nematodes to be Considered

Anguina ..... Seed & Leaf Gall Nematodes
Aphelenchoides..... Bud, Leaf & Foliar Nematodes
Bursaphelenchus..... Pine Wood Nematode
Ditylenchus..... Stem & Bulb Nematodes
Globodera..... Potato Cyst Nematodes
Helicotylenchus ..... Spiral Nematodes
Hemicycliophora ..... Sheath Nematodes
Heterodera..... Cyst Nematodes
Heterorhabditis..... Insect Biocontrol Nematodes
Meloidogyne ..... Root Knot Nematodes
Morulaimus..... Australian Sting Nematodes

Paratrichodorus ..... Stubby-Root Nematode
Pratylenchus ..... Root Lesion Nematodes
Radopholus ..... Burrowing Nematodes
Scutellonema ..... Spiral Nematodes
Steinernema ..... Insect Biocontrol Nematodes
Tylenchorhynchus ..... Stunt Nematodes
Tylenchulus ..... Citrus Nematode
Tylodorus .....
Xiphinema ..... Dagger Nematodes
Tylenchida ..... Minor Plant Parasites
Rhabditida ..... Microbial-Feeding Nematodes
Mononchida ..... Predatory Nematodes
Dorylaimida ..... Omnivorous Nematodes
Areolaimida ..... Omnivorous Nematodes

Actual list depends on participants interests.

Course Delivery & Materials

This is designed as a laboratory-based, hands-on course supported by lectures and discussion. The workshop will be held in laboratories and lecture rooms at the Waite Campus of the University of Adelaide. A practical manual containing outlines of topics covered, recipes for specific techniques, a key, a glossary and a bibliography of suitable references will be provided at the beginning of the course. Participants are encouraged to bring fixed material which they may wish to work on.

Course Fees

The workshop fee will be $2000 (AUD, excl GST where applicable). The fee is payable after notification that a minimum number of participants has been met. On acceptance registration, an invoice will be sent, which can be paid by credit card, or many other means (Money Order, cheque payable to "CSIRO, Nematode Identification" (ABN 41687119230), direct transfer or BPAY). The fee covers participation, the handbook and the provision of consumables such as fixatives, slides, and culture media. Tea and coffee and a course mixer will also be provided. Travel costs, accommodation, and meals are not included in the fee. The workshop requires 9 participants to proceed.

Accommodation/Meals

A variety of food outlets are available around the venue. Please indicate on the form if you require details from the workshop co-ordinator. Participants should make their own accommodation arrangements. The coordinators can supply lists of potential accommodations, with both low-cost student accommodation at the University and hotels of various standards nearby.

For more information

Dr Mike Hodda mike.hodda@csiro.au ph (02) 6246 4371
Dr Kerrie Davies Kerrie.davies@adelaide.edu.au

Helpful information for the organizers

It will help the organizers adjust the course to participants' interests and experience if the following information is provided:

University or other Tertiary Education: institution, degree, subjects with approx. dates?

Experience in nematology?

Main interests in particular aspects of plant, insect or soil nematology?

Other queries or preferences?

1. Monday 2 December

0900	Lecture	Introduction to course, housekeeping What is a nematode and what is not a nematode? (MH)
1000	Lecture	Nematodes and their basic anatomy (KD)
1100	Morning tea	
1130	Lecture	Nematode physiology and implications for quarantine, survival (KD)
1230	lunch	
1330	Practical	Sampling plant and insect nematodes from a variety of situations on campus (agricultural & native), set up some extractions (KD + MH + DP)
1500	Afternoon tea	
1530		Continue practical
1700	Finish	

2. Tuesday 3 December

0900	Lecture	Nematode ecology: distribution(MH)
1000	morning tea	
1030	Practical	Complete extraction of nematodes from samples taken Monday using other methods if required, viewing, counting (MH + KD + DP)
1230	Lunch	
1330	Lecture	Nematode ecology: trophic and other groupings (MH)
1430	Practical	Identification of major trophic types of nematodes (MH)
1500	Afternoon tea	
1530		Continue practical (MH)
1700	Finish	

3. Wednesday 4 December

0900	Lecture	Sampling background and theory, sampling for different purposes, bait selection (MH)
1000	Morning tea	
1030	Lecture	Population dynamics (KD)
1130	Practical	Mounting and examination of nematodes (KD)
1300	Lunch	
1400	Lecture	Reproduction, hatching, life cycles, host ranges (KD)
1500	Practical	Preparation of nematodes for microscopic examination, fixing and mounting (MH + KD + SS) rapid methods, lactoglycerol, processing (KD)
1800	Finish	

4. Thursday 5 December

0900	Lecture	Phylogeny, evolution and systematics to order level (MH)
0930	Lecture	Nematode disinfestation (MH)
1000	Morning tea	
1030	Lecture	Nematode systematics and identification of species (MH)
1130	Practical	Identification of nematode species, characteristics of major pest species in Australia (Root Knot Nematode, Cyst Nematodes, Root-Lesion Nematode, Spiral Nematode, Dagger Nematode, Stunt Nematode, Pine Wilt Nematode, other entomophilics, and non-pathogenic species) (MH + KD + DP)
1230	Lunch	
1330	Practical	Self-paced examination of nematodes (MH + KD + DP)
1500	Lecture	Species in plant-parasitic nematodes: the genus *Pratylenchus*, *Radopholus* & *Aphelenchoides* (Root Lesion, Burrowing & Leaf Nematodes) (MH)
1530	Lecture	Species in an Entomophilic nematode: the *Schistonchus* group (Fig Wasp Nematodes) (KD)
16000	Lecture	Molecular species identification (DP + MH)
1900	Informal course dinner	Local restaurant

5. Friday 6 December

0900	Lecture	Major pest genera, soil-dwelling pests of plants (KD)
1000	Morning tea	
1030	Lecture	Movement and dispersal of nematodes, hygiene and quarantine (MH)
1100	Lecture	Major pest genera, insect associates and pests of aerial parts of plants (KD)
1200	Practical	Identification of unknowns, revision as necessary, specific topics requested by participants (MH + KD + SS)
1230	Lunch	
1330		Continue identification
1400	Practical	Identification of unknowns, revision as necessary, specific topics requested by participants (MH + KD)
1500	Lecture	Molecular identification of nematodes in mixtures (DP + MH)
1600	Practical	Self-paced examination of nematodes (MH + KD + SS)
1700	Course close, evaluation	Presentation of certificates
1730	Finish	

2019/2020 Nematology Conferences

7TH INTERNATIONAL CEREAL NEMATODES SYMPOSIUM

Date: 3- 6th November 2019
Venue: New Delhi, India
Website: https://www.cimmyt.org/events/7th-international-cereal-nematodes-symposium/

7TH INTERNATIONAL CONGRESS OF NEMATOLOGY

Date: 3-8th May 2020
Venue: Antibes Juan-les-Pins, France
Website: https://www.alphavisa.com/icn/2020/index.php