

NAME OF CENTRE:

Who Collaborating Centre for the Molecular Epidemiology of Parasitic Infections

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HEAD OF CENTRE: Professor R.C.A. Thompson

DATE OF DESIGNATION: 19th November, 1990

TERMS OF REFERENCE:

1. To participate in WHO-coordinated research on the surveillance, epidemiology and control of parasite infections with particular reference to the identification and characterisation of the aetiological agents of zoonotic diseases including giardiasis, cryptosporidiosis and echinococcosis.
2. To develop, evaluate and standardise reproducible biochemical and molecular procedures for the differentiation and characterisation of parasite variants with particular reference to the impact of heterogeneity within and between parasite populations on epidemiology and control.
3. To collaborate with WHO Member States in the identification and characterisation of parasite isolates and to establish and maintain a reference collection of parasite isolates.
4. To collaborate in the training of workers from other countries in various laboratory techniques involved in the molecular characterisation of parasites.

1. RESEARCH

1.1. Molecular epidemiology of enteric protozoan infections

The Centre continues to receive isolates of *Giardia* and *Cryptosporidium*, and more recently *Blastocystis*, from laboratories throughout the world for genotyping, and in addition has ongoing projects on the epidemiology of infections caused by these parasites in Vietnam, Thailand, Laos, Pakistan, USA and Europe. These studies have contributed to an understanding of the epidemiology, transmission patterns, zoonotic potential and taxonomy of these protozoan pathogens. As a result of these activities the zoonotic potential of all three organisms has been determined through studies in defined endemic foci. Cattle remain the principal zoonotic source of infection for humans with *C. parvum* (= *C. pestis*), either directly or through contaminated water. However, it is now clear that there are several 'strains' of this species some of which appear not to be zoonotic raising questions about the zoonotic significance of infections in cattle. The main source of zoonotic *Giardia* are dogs and this has now been convincingly demonstrated through studies in temple communities in Thailand. However, although dogs commonly harbour infections with zoonotic genotypes of *Giardia* the actual frequency of zoonotic transmission remains to be determined. Current studies in Vietnam and the USA will provide additional data. The emerging pathogen *Blastocystis* has been shown to be ubiquitous in numerous species of mammals. The Centre has been undertaking studies in a number of geographical areas and host assemblages. Strains/species of the parasite are shared by humans and numerous other mammalian species including wildlife. Zoo-based studies have shown that non-human primates are a source of human infections, but other wildlife species also harbour potentially zoonotic forms of the parasite. In addition to the epidemiological significance of these studies, an important outcome has also been the establishment of a clearer nomenclature for the aetiological agents, and in the case of *Giardia*, a revised taxonomy clearly separating zoonotic and non-zoonotic species.

1.2. Molecular epidemiology of pig associated zoonoses in Laos

The central aim of these activities which commenced in late 2007 is to establish the evidence base regarding the presence and socioeconomic impact of pig-associated zoonoses in Laos and to identify and implement appropriate and sustainable veterinary public health interventions. The project is supported by the Australian Centre for International Agricultural Research and is being jointly implemented by the Lao Department of Livestock and Fisheries and Murdoch University. The specific aims of the project are to: (1) establish the evidence base in terms of prevalence, distribution and socioeconomic impacts of pig associated zoonoses in Laos; (2) determine the risks associated with human and pig transmission at the village level and identify appropriate and sustainable disease control strategies; (3) implement and test the effectiveness and adoption of control measures to minimise disease impacts on smallholder producers and the wider community; and (4) develop appropriate regional and national communication strategies for the wider uptake of project outcomes to manage pig associated zoonoses. Cross sectional prevalence surveys of pigs at slaughter points, and dogs, in four northern provinces of Laos are ongoing. Initial results have confirmed that *Trichinella* is prevalent and genotypically conforms to *T. spiralis*. Human survey work will commence in 2009. Correlating taeniid prevalence in pigs and dogs suggests that *Taenia hydatigena* may reduce the abundance and impact of *T. solium* through inter-specific competition.

The WHO CC was asked to evaluate the parasitology section at the National Health Laboratory in Vientiane in April 2008 in terms of personnel and infrastructure capability for undertaking parasitological diagnosis. We also conducted laboratory training of local staff in the specific techniques required for detecting parasites in pigs, dogs and humans.

1.3. Molecular epidemiology of food-borne zoonoses

Several projects were undertaken, and are ongoing, with colleagues in Thailand at Mahidol University and Phramongkutklao Medical College, in Bangkok; and colleagues in Vietnam from the National Institute of Hygiene and Epidemiology in Hanoi. These projects are concerned with the epidemiology of food borne zoonoses including enteric protozoa and flukes. The centre has developed a range of PCR-based tools for the direct characterisation of parasite stages in faeces and tissues, as well as comprehensive questionnaires for use at the village level in order to identify risk factors. Using a new PCR-based approach, Centre researchers demonstrated that the range of *Clonorchis sinensis* now extends to central Thailand. The Centre was also actively involved, in collaboration with colleagues at NIH in the USA (M Grigg) on the development of new genotyping tools for the detection and characterisation of isolates of *Toxoplasma* from tissues. These have been used effectively to demonstrate that *Toxoplasma* is far common in meat, particularly poultry, than previously considered to be the case. Genetic studies have also shown that variation in *Toxoplasma* is far greater than concluded from previous studies, and that virulent strains exist in wildlife that may pose a risk to humans from the consumption of game meat.

The Centre was also invited to join the Parasitic Diseases Task Force of The Foodborne Diseases Burden Epidemiology Reference Group (FERG) and is providing data on the global burden of intestinal protozoal diseases (giardiasis, amoebiasis, cryptosporidiosis, blastocystosis, cylosporiasis, isosporiasis)

1.4. Molecular epidemiology of echinococcosis

As with *Giardia* and *Cryptosporidium*, the Centre's role in characterising isolates of *Echinococcus* from throughout the world has led to the identification of new species of *Echinococcus*, including *E. equinus* (non-zoonotic) and *E. ortleppi* (zoonotic) that are maintained in horses and cattle respectively. Collaborative projects have also determined that the emergence of cystic echinococcosis in cervids in Canada is unlikely to be of public health significance with the discovery that the aetiological agent is the cervid strain. However, perpetuation of the life cycle in farmed elk is a result of poor husbandry. The Centre has also been involved in an investigation characterising *Echinococcus* from food producing animals in Western India in collaboration with colleagues from the Bombay Veterinary College and the University of Queensland. This study has demonstrated that in India the Buffalo (G3), Cattle (G5), Sheep (G1) and Tasmanian Sheep (G2) strains of *E. granulosus* exist. Except for the Buffalo strain (G3), all other strains present in India have been shown to infect humans. This has important implications for hydatid control and public health. Finally, a recently initiated collaborative study with the Veterinary School in Saskatoon, is monitoring and mitigating parasitic risks to human health in an Indigenous community from Northern Saskatchewan. The emphasis will be on echinococcosis and the role of community dogs in transmission.

1.4. Molecular epidemiology of trypanosomiasis in Africa

Loop-mediated isothermal amplification of DNA is a novel technique that rapidly amplifies target DNA under isothermal conditions. Working with colleagues from the Trypanosomiasis Research Centre in Kenya and the Foundation for Innovative New Diagnostics in Geneva, the Centre has developed a LAMP test from the SRA gene of *Trypanosoma brucei rhodesiense* and used it to detect parasite DNA from processed and heat-treated infected blood samples. The test, which does

not require sophisticated equipment such as a thermocycler, was trialled in humans in several sites in Africa and proved to be reproducible, sensitive, specific and robust under field conditions providing results within 35 minutes. The test thus has great potential for the diagnosis of *Trypanosoma* infections in endemic regions.

2 TRAINING

- 2.1 Scientists from Vietnam, Thailand, Canada, Belgium, United Kingdom, Denmark, and the USA visited the Centre during 2007 and 2008 for periods of between 1 – 12 months for training in parasite diagnosis, molecular epidemiological techniques and surveillance with reference to *Echinococcus* and other taeniids, GI nematodes, *Trypanosoma*, *Giardia*, *Cryptosporidium*, *Blastocystis* and *Toxoplasma* .
- 2.2 Funding was received from Murdoch University, the Australian Research Council and the Australian Council for International Agricultural Research (ACIAR), DANIDA, Endeavour foundation, to develop training programmes in parasite diagnosis, surveillance and molecular epidemiological techniques for trainees and collaborators in several institutes in SE Asia, Canada and Europe. In addition to training undertaken at Murdoch University, we ran courses and training in Laos.
- 2.3 Programmes for research students from Australia and overseas were continued in parasitology, zoonoses, molecular parasitology, surveillance and biosecurity.

3 SPECIFIC ACTIVITIES

- 3.1 The Centre has continued to maintain and expand a large reference collection of parasite species and genotypes, and to provide isolates from the collection as well as scientific literature upon request.
- 3.2 The Centre has continued to establish a network of collaborating scientists in many parts of the world working on the identification and strain/genotypic characterisation of protozoan and helminth parasites.
- 3.3 Scientists from the Centre were invited to participate at international conferences and expert working groups on parasite zoonoses, food-borne enteric protozoa, *Cryptosporidium*, *Echinococcus*, *Giardia*, *Toxoplasma*, and biosecurity in Canada, Belgium, Thailand, Switzerland and the USA.
- 3.4 There were 31 publications and 48 conference presentations during this reporting period.

PUBLICATIONS

CHAPTERS AND REVIEWS IN BOOKS

1. Thompson, RCA, Traub, RJ and Parameswaran, N. 2007. Molecular epidemiology of foodborne parasitic zoonoses. In: *Food-Borne Parasitic Zoonoses* (Eds Murrell, KD and Fried, B.), Springer pp 383-415.
2. Palmer, CS, Traub, RJ, Robertson, ID, Hobbs, RP, Elliot, A, While, L, Rees, R, and Thompson RCA 2007. The veterinary and public health significance of hookworm in dogs and cats in Australia and the status of *A. ceylanicum*. *Veterinary Parasitology* 145:304-313.
3. Njiru, ZK, Constantine, CC, Gitonga, PK, Thompson, RCA, Reid, SA 2007. Genetic variability of *Trypanosoma evansi* isolates detected by inter-simple sequence repeat anchored-PCR and microsatellite. *Veterinary Parasitology*, 147: 51-60.
4. Stensvold, CR, Traub, RJ, von Samson-Himmelstjerna, G, Jespersgaard, C, Nielsen, HV, Thompson, RCA. 2007. *Blastocystis*: Subtyping isolates using pyrosequencing technology. *Experimental Parasitology* 116:111-119.
5. Stensvold, CR, Suresh, GK, Tan, KS, Thompson, RCA, Traub, RJ, Viscogliosi, E, Yoshikawa, H. and Clark CG. Terminology for *Blastocystis* subtypes - a consensus. *Trends in Parasitology* 23:93-96.
6. Inpankaew, T, Traub, R, Thompson, RCA, Sukthana, Y. 2007. Canine parasitic zoonoses and temple communities in Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health* 38:247-255.
7. Barutzki, D, Thompson, RCA, Wielinga, C, Parker, U. and Schaper, R. 2007. Observations on *Giardia* infection in dogs from veterinary clinics in Germany. *Parasitology Research* 101:153-156.
8. Wielinga, CM, and Thompson, RCA. 2007. Comparative evaluation of *Giardia duodenalis* sequence data. *Parasitology* 134: 1795-1821.
9. Leonhard, S, Pfister, K, Beelitz, P, Wielinga, C. and Thompson, RCA. 2007. The molecular characterisation of *Giardia* from dogs in Southern Germany. *Veterinary Parasitology* 150: 33-38.
10. Cruz-reyes, A, Constantine, CC, Boxell, AC, Hobbs, RP and Thompson, RCA. 2007. *Echinococcus granulosus* from Mexican pigs is the same strain as that in Polish pigs. *Journal of Helminthology* 81: 287-292.
11. Traub, RJ, Hobbs, RP, Adams, PJ, Behnke, JM, Harris, PD, Thompson, RCA. 2007. A case of mistaken identity – Reappraisal of the species of canid and felid hookworms (*Ancylostoma*) present in Australia and India. *Parasitology* 134: 113-119.
12. Njiru, ZK, Mikosza, ASJ, Matovu, E, Enyaru, JCK, Ouma, JO, Kibona, SN, Thompson, RCA and Ndungu, JM 2008. African trypanosomiasis: sensitive and rapid detection of the sub-genus *Trypanozoon* by loop-mediated isothermal amplification (LAMP) of parasite DNA. *International Journal for Parasitology* 38:589-599.

13. Palmer CS, Thompson, RCA, Traub, RJ, Rees, R. And Robertson, ID. 2008. National study of the gastrointestinal parasites of dogs and cats in Australia. *Veterinary Parasitology* 151: 181-190. .
14. Salb, AL, Barkeman, WB, Elkin, BT, Thompson, RCA, Whiteside, RCA, Black, SR, Dubey, JP and Kutz, SJ. 2008. Parasites in dogs in two northern canadian communities: implications for human, dog, and wildlife health. *Emerging Infectious Diseases* 14:60-63.
15. Njiru, ZK, Mikosza, ASJ, Armstrong, T, Ndungu, JM. And Thompson, RCA. 2008. Loop-mediated isothermal amplification (LAMP) method for rapid detection of *Trypanosoma brucei rhodesiense*. *PLoS Neglected Tropical Diseases* 2:e147
16. Steuart, RF, O'Handley, R, Lipscombe, RJ, Lock, RA, Thompson, RC. 2008. Alpha 2 giardin is an assemblage A-specific protein of human infective *Giardia duodenalis*. *Parasitology*,135: 1621-1627.
17. Kutz, SJ, Thompson, RA, Polley, L, Kandola, K, Nagy, J, Wielinga, CM, Elkin, BT. 2008. *Giardia* assemblage A: human genotype in muskoxen in the Canadian Arctic. *Parasites and Vectors*, 1: 32.
18. Smith, A, Clark, P, Averis, S, Lymbery, AJ, Wayne, AF, Morris, KD, Thompson, RC. 2008. Trypanosomes in a declining species of threatened Australian marsupial, the brush-tailed bettong *Bettongia penicillata* (Marsupialia: Potoroidae). *Parasitology*, 135: 1329-1335.
19. Traub, RJ, Inpankaew, T, Sutthikornchai, C, Sukthana, Y, Thompson, RC.2008. PCR-based coprodiagnostic tools reveal dogs as reservoirs of zoonotic ancylostomiasis caused by *Ancylostoma ceylanicum* in temple communities in Bangkok. *Veterinary Parasitology*, 155: 67-73.
20. Thompson, RC. 2008. The taxonomy, phylogeny and transmission of *Echinococcus*. *Experimental Parasitology*, 119: 439-46.
21. Conlan, J, Khounsy, S, Inthavong, P, Fenwick, S, Blacksell, S, Thompson, RC. 2008. A review of taeniasis and cysticercosis in the Lao People's Democratic Republic. *Parasitology Int.* 57: 252-255.
22. Palmer, CS, Traub, RJ, Robertson, ID, Devlin, G, Rees, R, Thompson, RCA. 2008. Determining the zoonotic significance of *Giardia* and *Cryptosporidium* in Australian dogs and cats. *Veterinary Parasitology*, 154: 142-147.
23. Palmer, CS, Thompson, RCA, Traub, RJ, Rees, R, Robertson, ID. 2008. National study of the gastrointestinal parasites of dogs and cats in Australia. *Veterinary Parasitology*,151: 181-90.
24. Barutzki, D, Schaper, R. and Thompson, RCA. 2008. Die giardiose des hundes – eine weit verbreitete erkrankung in Deutschland. *Enke Verlag, Kleintier konkret*, SI; 17-23.
25. Borowski H, Clode PL, Thompson RCA. 2008. Active invasion and/or encapsulation?

- A reappraisal of host-cell parasitism by *Cryptosporidium*. *Trends in Parasitology* 24: 509-516.
26. Thompson, RCA, Palmer, CS, O'Handley, R. 2008. The public health and clinical significance of *Giardia* and *Cryptosporidium* in domestic animals. *Veterinary Journal*, 177: 18-25.
 27. Traub, RJ, Macaranas, J, Mungthin, M, Leelayoova, S, Cribb, T, Murrell, KD, Thompson, RCA. 2009. A New PCR-Based Approach Indicates the Range of *Clonorchis sinensis* Now Extends to Central Thailand. *PLoS Negl Tropical Diseases*, 3(1) : e367.
 28. Monis, PT, Caccio, SM, Thompson, RCA. 2009. Variation in *Giardia*: towards a taxonomic revision of the genus. *Trends in Parasitology*, 25: 93-100.
 29. Thompson, RCA, Colwell, DD, Shury, T, Appelbee, AJ, Read, C, Njiru, Z, Olson, ME. 2009. The molecular epidemiology of *Cryptosporidium* and *Giardia* infections in coyotes from Alberta, Canada, and observations on some cohabiting parasites. *Veterinary Parasitology*, 159: 167-70.
 30. Palmer, CS, Robertson, ID, Traub, RJ, Rees, R, Thompson, RCA. 2009. Intestinal parasites of dogs and cats in Australia: The veterinarian's perspective and pet owner awareness *Veterinary Journal* (in press)
 31. Thompson, RCA, Kutz, SJ, Smith, A. 2009. Parasite zoonoses and wildlife: Emerging issues. *International Journal of Environmental Research and Public Health* (in press)

Conference Abstracts

1. Armstrong, T, Best, WM, Charman, W, Laverty, C, Luna G, Sims, CG, Thompson, RCA. A novel and highly potent class of compounds for the treatment of Trypanosomiasis. Keystone Symposia, Drugs Against Protozoan Parasites, Tahoe City, California, 28th January – 1st February, 2007.
2. Thompson, RCA. The impact of *Giardia* on science and society. International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.
3. Barutzki, D, Thompson, RCA, Wielinga, C, Schaper, R. *Giardia* spp. In dogs; Genotyping of 75 samples from randomly selected dogs presented at local veterinary clinics. International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.
4. Kutz, S, Thompson, RCA. Wildlife with *Giardia*: Villains or victims and vectors? International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.
5. Ralston, B, Thompson, RCA, Pethick, D, McAllister, T, Olson, M. A comparative study of *Cryptosporidium andersoni* and *Giardia* infections in feedlot cattle of Western Australia and Alberta, Canada. International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.

6. Hijjawi, NS, Boxell, AC, Thompson, RCA. Recent advances in the development of *Cryptosporidium* parasite. International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.
7. Steuart, R, O'Handley, R, Lipscombe, R, Thompson, RCA. Comparative proteomics of human infective *Giardia duodenalis*. International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.
8. Steuart, R, O'Handley, R, Lipscombe, R, Thompson, RCA. *Giardia duodenalis*: Novel proteins of an ancient eukaryote. International *Giardia* and *Cryptosporidium* Conference, Morelia, Michoacán, México, 13-18th May, 2007.
9. Kutz S, Thompson, RCA, Kandola, K, Nagy, J, Wielinga, C, Lydden, P, Elkin, B. *Giardia* assemblage A: Human genotype in muskoxen in the Canadian Arctic. Annual Conference of the Wildlife Disease Association, Colorado, USA, August 12-17, 2007.
10. Salb, AL, Barkema, HW, Elkin, BT, Thompson, RCA, Whiteside, DP, Black, SR, Dubey, JP, Ellis, JA, Krakowka, S, Kutz, SJ. Parasitic and viral diseases of dogs in two Northern Canadian communities and implications for wildlife and human health. Annual Conference of the Wildlife Disease Association, Colorado, USA, August 12-17, 2007.
11. Steuart, R, O'Handley, R, Lipscombe, R, Thompson, RCA. Comparative proteomics of human infective *Giardia duodenalis*. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.
12. Parameswaran, N, O'Handley, R, Thompson, RCA. Development of an ELISA for the detection of *Toxoplasma gondii* antibodies in macropod marsupials. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.
13. Ash, A, Lemon, J, Thompson, RCA. Parasites of the African Painted Dog (*Lycaon pictus*) in wild and captive populations: potential conservation impacts. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.
14. Burmej, H, Smith, A, Lymbery, A, Wayne, A, Morris, K, Fenwick, S, Thompson, RCA. The biodiversity and host-specificity of fleas in the woylie (*Bettongia penicillata*). ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.
15. Parkar, U, Traub, R, Mehraj, V, Hijjawi, N, Thompson, RCA. Molecular characterisation of *Blastocystis* and *Giardia duodenalis* isolates found among children in Jordan and Pakistan. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.
16. Walters, JA, Robertson, ID, Thompson, RCA, Lymbery AJ. *Giardia* and *Cryptosporidium* infection in Western Australian childcare centres. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.
17. Borowski, H, Clode, P, Thompson, RCA. *Cryptosporidium parvum*: new insights into the invasion process, developmental stages and effects on host cells. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Canberra, ACT, 8-11 July, 2007.

18. Parkar, U, Traub, RJ, Vitali, Thompson, RCA. Molecular characterisation of *Blastocystis* isolates found in animals and zoo-keepers at the Perth Zoo. The 21st International Conference of the World Association for the Advancement of Veterinary Parasitology (WAAVP), Gent, Belgium, 19-23 August, 2007.
19. Ralston, BJ, Thompson, RCA, Pethick, D, McAllister, TA Olson, ME. Molecular characterization, longitudinal prevalence and impact on performance of *Cryptosporidium andersoni* and *Giardia* infections in feedlot cattle of Western Australia and Alberta, Canada. The 21st International Conference of the World Association for the Advancement of Veterinary Parasitology (WAAVP), Gent, Belgium, 19-23 August, 2007.
20. O'Handley, R, Fenwick, S, Thompson, RCA. *Toxoplasma* in Australian Marsupials: analysis of pouch young of naturally infected wild kangaroos for evidence of vertical transmission. The 21st International Conference of the World Association for the Advancement of Veterinary Parasitology (WAAVP), Gent, Belgium, 19-23 August, 2007.
21. Palmer, CS, Robertson, ID, Traub, RJ, Rees, R, Mencke, N, Thompson, RCA. Nation wide survey of intestinal parasites in dogs and cats in Australia. The 21st International Conference of the World Association for the Advancement of Veterinary Parasitology (WAAVP), Gent, Belgium, 19-23 August, 2007.
22. O'Handley, R and Thompson, RCA. Development of an ELISA for the detection of *Toxoplasma gondii* antibodies in macropod marsupials.
23. Steuart R, O'Handley, R, Lipscombe, R, Thompson, RCA. *Giardia duodenalis*: novel proteins from an ancient eukaryote. The 21st International Conference of the World Association for the Advancement of Veterinary Parasitology (WAAVP), Gent, Belgium, 19-23 August, 2007.
24. Barutzki, D, Thompson, RCA, Wielinga, C, Schaper, R. *Giardia spp.* in dogs: Genotyping of 75 samples from randomly selected dogs presented at local veterinary clinics. The 21st International Conference of the World Association for the Advancement of Veterinary Parasitology (WAAVP), Gent, Belgium, 19-23 August, 2007.
25. Clark, P, Thompson, RCA, Wayne, A, Averis S. Trypanosomes in relation to the diagnosis of woylie declines: prevalence and molecular characterisation. The Wildlife Disease Association (Australasian Section) Annual Conference, Dryandra Woodland, WA, September 22-28, 2007.
26. Smith, A, Lymbery, A, Elliot, A, Parkar, Unaiza, Wayne A, Thompson RCA. Prevalence and diversity of woylie endoparasites: from individuals to populations and sympatric species. The Wildlife Disease Association (Australasian Section) Annual Conference, Dryandra Woodland, WA, September 22-28, 2007.
27. Parameswaran, N, O'Handley, R, Wayne, A, Smith, A, Eden, P, Lymbery, A, Morris, K, Thompson, RCA. *Toxoplasma* in Woylies. The Wildlife Disease Association (Australasian Section) Annual Conference, Dryandra Woodland, WA, September 22-28, 2007.
28. Burmej, H, Smith, A, Lymbery, A, Wayne, A, Morris, K, Fenwick, S, Thompson, RCA. The biodiversity, ecology and importance of ectoparasites in the woylie (*Bettongia penicillata*) and sympatric species. The Wildlife Disease Association (Australasian Section) Annual Conference, Dryandra Woodland, WA, September 22-28, 2007.

29. Parkar, Unaiza, Traub, Rebecca, Vitali, Simone, Robertson, Ian, Thompson, RC Andrew. Characterisation of *Blastocystis* isolates in animals and zookeepers at the Perth Zoo. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Glenelg South Australia, 6-9 July, 2008.
30. Steuart, Rob, O'Handley, Ryan, Lipscombe, Richard, Lock Robert, Thompson, RC Andrew. Protein variation in the human infective genetic assemblages of *Giardia duodenalis*. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Glenelg South Australia, 6-9 July, 2008.
31. Koh, Wan Hon, Steuart, Robert FLS, Marano, Robert J, Thompson, RC Andrew. Is *Giardia duodenalis* capable of genetic exchange? ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Glenelg South Australia, 6-9 July, 2008.
32. Nguyen, Lan Thi Phong, Thompson, RC Andrew. The molecular epidemiology of zoonotic protozoan infections in a rural area of Vietnam. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Glenelg South Australia, 6-9 July, 2008.
33. Ash, Amanda, Lymbery, Alan J, Lemon, John, Thompson, RC Andrew. Parasites of the African painted dog (*Lycaon pictus*) and captive populations: potential conservation impacts. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Glenelg South Australia, 6-9 July, 2008.
34. Parameswaran Nevi, Grigg, Michael, O'Handley, Ryan, Thompson, RC Andrew. Molecular characterisation of *Toxoplasma gondii* DNA in wild Australian marsupials. ASP & ARC/NHMRC Research Network for Parasitology Annual Conference, Glenelg South Australia, 6-9 July, 2008.
35. Averis, S, Thompson, A, Lymbery, A, Wayne, A, Morris, K, Smith, A. Characterisation of trypanosomes from Australian marsupials. Xth European Multicolloquium of Parasitology, Paris, 24-28 August, 2008.
36. Thompson, RCA, Caccio, SM, Monis, PT. Variation in *Giardia* : towards a taxonomic revision of the genus. Xth European Multicolloquium of Parasitology, Paris, 24-28 August, 2008.
37. Smith, A, Clark, P, Averis, S, Lymbery, A, Wayne, A, Morris, K, Thompson, A. A novel trypanosoma sp and its role in the decline of a threatened species of Australian marsupial, the Brush-Tailed Bettong (*Bettongia penicillata*). Xth European Multicolloquium of Parasitology, Paris, 24-28 August, 2008.
38. Inpankaew, Tawin, Pinyopanuwat, Nongnuch, Chimnoi, Wissanuwat, Thompson, R.C. Andrew, Jittapalapong, Sathaporn. Prevalence and genotyping of *Cryptosporidium* spp. from dairy cows in the central part of Thailand. Joint International Tropical Medicine Meeting, Bangkok, Thailand, 13-14 October, 2008.
39. Thompson, R.C. Andrew. Transmission and life cycle patterns of *Toxoplasma*. Joint International Tropical Medicine Meeting, Bangkok, Thailand, 13-14 October, 2008.
40. Ash, A, Lymbery, A, Lemon, J, Thompson, RCA. Parasites of the African painted dog (*Lycaon pictus*) in wild and captive populations: potential conservation impacts.

Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.

41. Burmej, H, Smith, A, Lymbery, A, Wayne, A, Morris, K, Abdad, Y, Fenwick, S, Thompson, RCA. Describing ectoparasite biodiversity in threatened Western Australia mammals: new methods and challenges. Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.
42. Wayne, Adrian, Ward, Colin, Maxwell, Marika, Vellios, Chris, Wilson, Ian, Wayne, Julia, Thompson, Andrew, Reiss Andrea, Eden, Paul, Richards, Jacqui. Diagnosing the recent woylie (*Bettongia penicillata*) collapse in south-western Australia. Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.
43. Parkar, Unaiza, Traub, Rebecca, Vitali, Simone, Wayne, Adrian, Morris, Keith, Thompson, Andrew. Characterisation of *Blastocystis* isolates from zoo animals and native wildlife. Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.
44. Smith, Andrew, Clark, Phillip, Averis, Susana, Lymbery, Alan, Wayne, Adrian, Morris, Keith, Thompson, Andrew. The role of trypanosomes in the decline of a threatened species of Australian marsupial, the brush-tailed bettong (*Bettongia penicillata*). Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.
45. Parameswaran, Nevi, Pan Shuting, Lymbery, Alan, Smith, Andrew, Wayne, Adrian, Morris, Keith, Grigg, Michael, Thompson, Andrew. *Toxoplasma* in Australian wildlife – food for thought? Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.
46. Reiss, A, Eden, P, Wayne, A, Pacioni, C, Nicholls, P, Thompson, A. Veterinary investigation of population declines of the woylie (*Bettongia penicillata*) in south-west Western Australia. Australasian Wildlife Management Society 21st Annual Conference, Fremantle, Western Australia, 24-27 November, 2008.
47. Armstrong, Tanya, Thompson Andrew, Clode Peta. Observations on the cytodifferentiation of *Echinococcus multilocularis* *in vitro*. American Society of Tropical Medicine and Hygiene 57th Annual Meeting, New Orleans, Louisiana, USA. 7-11 December, 2008.
48. Thompson, Richard C A, Armstrong Tanya, Best, Wayne M, Charman, Susan, Don, Robert, Lavery, Caroline, Luna Giuseppe, Colette, Colette. A novel and highly potent class of compounds for the treatment of Trypanosomiasis. American Society of Tropical Medicine and Hygiene 57th Annual Meeting, New Orleans, Louisiana, USA. 7-11 December, 2008