

RAT LUNGWORM DISEASE

A SCIENTIFIC WORKSHOP

**ALA MOANA HOTEL
HONOLULU, HAWAII**

AUGUST 16 - 18, 2011

Program and Abstracts



**Workshop supported by the National Institute of Food and Agriculture
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Tuesday 16 August

Arrival, pre-meeting refresher reception

Pre-meeting refresher reception

Meet at 4:50 pm on Tuesday, August 16, at the front desk of the Ala Moana Hotel. Look for Robert Cowie holding a sign saying: 'Angiostrongyliasis workshop - Aloha!'

or

Meet at 5:00 pm at 'Island Fine Burgers and Drinks' on the 4th floor of Ala Moana Shopping Center, on the Macy's end/mountain side of the mall. The first drink is on Rob and Jim! After that you are on your own. We will be in the outside open area. If you get lost in the mall, call Jim Hollyer's mobile phone at 808-782-3725 or Rob Cowie's at 808-541-7121.

Wednesday 17 August

Registration 7:30 am – 8:00 am

Welcome and purpose of the workshop (Cowie) 8:00 am – 8:10 am

The transdisciplinary objectives and goals of the workshop and the expected products

Introductions 8:10 am – 8:30 am

Information about the workshop (Hollyer) 8:30 am – 8:40 am

Protocol and procedures

The historical context in Hawaii (Wallace) 8:40 am – 9:00 am

The discovery of humans in Hawaii infected with *A. cantonensis*, and early epidemiological findings

Section 1. The biology, life cycle and hosts of *Angiostrongylus cantonensis*

Talk 1 (Cowie) 9:00 am – 9:20 am

Biology, taxonomy, identification, and life cycle of *Angiostrongylus cantonensis*

Talk 2 (Kim) 9:20 am – 9:40 am

Definitive, intermediate, paratenic, and accidental hosts of *Angiostrongylus cantonensis*, and its molluscan intermediate hosts in Hawaii

Talk 3 (Teem) 9:40 am – 10:00 am

Nonindigenous apple snails as hosts of *Angiostrongylus cantonensis* in the southeastern United States

BREAK----- 10:00 am – 10:20 am

Talk 4 (Eamsobhana, Lim & Yong) 10:20 am – 10:40 am

Genetic diversity of *A. cantonensis*

Talk 5 (Maldonado, to be presented by Thiengo) 10:40 am – 11:00 am

Taxonomy and transmission dynamics of *Angiostrongylus cantonensis* in *Rattus norvegicus* in Brazil

Section 2. Human infection by *Angiostrongylus cantonensis* around the world

Talk 6 (Lun) 11:00 am – 11:20 am

The current situation regarding angiostrongyliasis in mainland China

Talk 7 (Tsai) 11:20 am – 11:40 am

Angiostrongyliasis in Taiwan

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Talk 8 (Eamsobhana) 11:40 am – 12:00 noon
Angiostrongyliasis in Thailand

LUNCH ----- 12 noon – 1:00 pm

Talk 9 (Robinson, Lindo, Waugh & Todd) 1:00 pm – 1:20 pm
Angiostrongyliasis in Jamaica: 1994 to present

Talk 10 (Thiengo) 1:20 pm – 1:40 pm

Angiostrongyliasis in Brazil - an emerging disease, distribution and spread

Talk 11 (Park & Fox) 1:40 pm – 2:00 pm

Angiostrongylus cantonensis: epidemiology in the continental United States and Hawaii

Section 3. Clinical and diagnostic aspects of eosinophilic meningitis

Talk 12 (Howe) 2:00 pm – 2:20 pm

Potential treatments to aid in recovery of rat lungworm disease patients

Talk 13 (Johnson) 2:20 pm – 2:40 pm

Eosinophilic meningitis in a group of people returning from the Caribbean: clinical lessons learned

Talk 14 (Murphy) 2:40 pm – 3:00 pm

Brief summary of an angiostrongyliasis case from Hawaii with neurologic sequelae, and a summary of the medical treatment literature

BREAK----- 3:00 pm – 3:20 pm

Talk 15 (Gosnell & Kramer) 3:20 pm – 3:40 pm

Immunologic Response to *Angiostrongylus cantonensis*

Talk 16 (Sawanyawisuth) 3:40 pm – 4:00 pm

Differential diagnosis of CNS infections with focus on angiostrongyliasis

Talk 17 (Wilkins & Whelen) 4:00 pm – 4:20 pm

Laboratory algorithms for diagnosis of angiostrongyliasis

Talk 18 (Morassutti) 4:20 pm – 4:40 pm

Test development and perspectives for the future of lab diagnosis of angiostrongyliasis

Discussion and expectations for Day 2 4:40 pm – 5:00 pm

Dinner on your own

Thursday 18 August

Welcome to Day 2 8:00 am – 8:20 am

Section 4. Methods to detect *Angiostrongylus cantonensis* in hosts

Talk 19 (daSilva & Qvarnstrom) 8:20 am – 8:40 am

Detection of *Angiostrongylus cantonensis* and trends in geographic distribution

Talk 20 (Qvarnstrom & daSilva) 8:40 am – 9:00 am

Detection of *Angiostrongylus cantonensis* in intermediate, definitive and paratenic hosts (molecular and other methods)

Talk 21 (daSilva & Qvarnstrom) 9:00 am – 9:20 am

Collection of environmental samples for detection of *Angiostrongylus cantonensis*

Section 5. Risks and management of *Angiostrongylus cantonensis*

Talk 22 (Cowie) 9:20 am – 9:40 am

Pathways for transmission of angiostrongyliasis and associated risks

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Talk 23 (Yang) 9:40 am – 10:00 am

Invasion, spread, detrimental effects and control of the snail *Pomacea canaliculata*, an important vector of *Angiostrongylus cantonensis* in China

BREAK----- 10:00 am – 10:20 am

Talk 24 (Hollingsworth) 10:20 am – 10:40 am

Control and management of slug and snail vectors, with special reference to species in Hawaii

Section 6. How to keep the medical community informed and what clinicians should know

Talk 25 (Murphy) 10:40 am – 11:00 am

Ideas to disseminate knowledge of angiostrongyliasis to clinicians, and ideas for future clinical trials

Talk 26 (Johnson) 11:00 am – 11:20 am

Diagnostic considerations and options for clinicians

Section 7. How to inform the public

Talk 27 (Dixon) 11:20 am – 11:40 am

Community outreach and education on the island of Hawaii (the ‘Big Island’)

Talk 28 (Hollyer) 11:40 am – 12:00 noon

Extension, brochures, community meetings and follow-up

LUNCH ----- 12:00 noon – 1:00 pm

GROUP PHOTO----- 1:00 pm – 1:20 pm

Section 8. Group discussion to develop list of priority projects (Hollyer, moderator)

1:20 pm – 3:00 pm

Focus 1 Detection of *Angiostrongylus cantonensis* in intermediate / environmental / definitive hosts

Focus 2 Control of hosts in the field (rats, slugs/snails, paratenic hosts)

Focus 3 Public education to minimize chance of infection

Focus 4 Control of hosts/larvae on produce (washing/rinsing)

BREAK----- 3:00 pm – 3:20 pm

Section 8. continued 3:20 pm - 4:40 pm

Focus 5 Diagnosis

Focus 6 Treatment

Focus 7 Pathophysiology

Focus 8 Epidemiology

Wrap-up, thanks and closure

4:40 pm – 5:00 pm

Evening gathering

5:30 pm – Assagio’s restaurant, Ala Moana Shopping Center (optional / no host)

Departure

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ABSTRACTS

Abstracts of presentations are arranged alphabetically by the first author's last/family name. Numbers following the title of each talk correspond to the number of the talk in the program.

Biology, taxonomy, identification, and life cycle of *Angiostrongylus cantonensis* (1)

Robert H. Cowie

Pacific Biosciences Research Center, University of Hawaii, 3050 Maile Way, Gilmore 408,
Honolulu, Hawaii 96822, U.S.A.
cowie@hawaii.edu

Aspects of the basic biology of *Angiostrongylus cantonensis* are briefly introduced. *Angiostrongylus cantonensis* is a metastrongyloid nematode in the family Angiostrongylidae. First described in 1935 from rats in China, it was placed in the genus *Parastrongylus* in 1986, but most workers have not adopted this treatment. Taxonomy of *A. cantonensis* and related worms is largely based on adult morphology, notably the male bursa. Identification is also based on morphology, but identification of infective 3rd stage worms is difficult. The natural life cycle involves snails or slugs as the intermediate host and rats as the definitive host. Human infection, as accidental hosts, results in worms maturing in the brain, but dying there instead of moving back into the bloodstream, as in rats, thereby leading to eosinophilic meningitis.

Pathways for transmission of angiostrongyliasis and associated risks (22)

Robert H. Cowie

Pacific Biosciences Research Center, University of Hawaii, 3050 Maile Way, Gilmore 408,
Honolulu, Hawaii 96822, U.S.A.
cowie@hawaii.edu

Humans can become infected by 3rd stage worms by eating raw or under-cooked snails or slugs, the intermediate hosts, both deliberately and inadvertently. It may be possible to become infected by eating snail/slug slime (mucus) either on produce or as a result of handling snails/slugs, and (least likely) by consuming drinking water contaminated by snails or slugs. It is also possible to become infected by eating raw or under-cooked paratenic hosts such as freshwater shrimp, crabs and fish. Food preparation prior to cooking can leave debris from which infection can occur. Strategies for reducing human infection should include control of definitive and intermediate hosts, management of intermediate and paratenic hosts to reduce chances of accidental ingestion, and public education so that people do not eat raw intermediate and paratenic hosts and take care to clean vegetables/produce.

Detection of *Angiostrongylus cantonensis* and trends in geographic distribution (19)

Alex daSilva¹ & Yvonne Qvarnstrom²

Building 23, Mailstop D-64, 1600 Clifton Road, Atlanta, Georgia 30329, U.S.A.

¹ abs8@cdc.gov ² bvp2@cdc.gov

The geographic distribution of *Angiostrongylus cantonensis* has changed significantly during the past decade. This talk will focus on the new trends in detection of different stages of *Angiostrongylus cantonensis* in intermediate, definitive and paratenic hosts worldwide. The presentation will also briefly address the status of CDC projects in collaboration with groups in the U.S. and abroad.

Collection of environmental samples for detection of *Angiostrongylus cantonensis* (21)

Alex daSilva¹ & Yvonne Qvarnstrom²

Building 23, Mailstop D-64, 1600 Clifton Road, Atlanta, Georgia 30329, U.S.A.

¹ abs8@cdc.gov ² bvp2@cdc.gov

A number of different methods have been used to collect and analyze samples for the identification of *Angiostrongylus cantonensis*. In this talk we will discuss this topic, focusing on the standardization of protocols and development of standard operating procedures for international studies.

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Community outreach and education on the island of Hawaii (the 'Big Island') (27)

Marlena Castro Dixon

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marlena.dixon@doh.hawaii.edu

Due to an increase in severity of cases and media attention, community outreach efforts were revisited in 2009, to include an updated flier, radio interviews, and community presentations. The Puna district of the island of Hawaii (the 'Big Island') has been impacted the greatest by rat lungworm disease. The biggest challenge in disseminating information was that residents could not accept that limited information, testing, and treatment options were available. Some people wanted basic information while others requested great detail. Some responded better to information in 'pidgin' but others preferred English. Another challenge was to provide information to communities where residents did not read newspapers or watch television news. As a result, a community education group formed and assisted in disseminating information to these communities. But some residents never received information and there has been no decrease in cases. Information must be sent repeatedly and through different media, including free journals, local community newspapers, local television stations, and even social networking.

Angiostrongyliasis in Thailand – epidemiology and laboratory investigations (8)

Praphathip Eamsobhana

Department of Parasitology, Faculty of Medicine, Mahidol University, Bangkok 10700, Thailand
sipes@mahidol.ac.th

Cerebral angiostrongyliasis continues to affect the lives, health, and productivity of indigenous people living in northeastern areas of Thailand, where the parasite is endemic and the populace relish eating the local undercooked snail dish called 'koi-hoi'. Hundreds of suspected cases continue to be reported annually. The report will focus on the epidemiology and laboratory diagnosis of angiostrongyliasis in Thailand and provide valuable information to better understand this neurotropic nematode.

Genetic diversity of *Angiostrongylus cantonensis* (4)

Praphathip Eamsobhana¹, Phaik Eem Lim² & Hoi Sen Yong³

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² Institute of Biological Sciences, University of Malaya, 50603 Kuala Lumpur, Malaysia
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Phylogenetic trees have been constructed based on DNA sequences of the internal transcribed spacer 2 (ITS-2), small-subunit ribosomal RNA (SSU rRNA), cytochrome c oxidase subunit I (COI) and 66-kDa protein genes for *Angiostrongylus cantonensis*. Among these, the COI sequences could possibly be used for differentiating geographical isolates of *A. cantonensis*.

Immunologic Response to *Angiostrongylus cantonensis* (15)

William L. Gosnell & Kenton J. Kramer

Department of Tropical Medicine, Medical Microbiology and Pharmacology, John A. Burns
School of Medicine, 651 Ilalo Street, Honolulu, Hawaii 96813, U.S.A.
gosnell@hawaii.edu kramer@hawaii.edu

The human immunologic response against many helminth parasites such as *Angiostrongylus cantonensis* invokes an entirely distinct immune profile than from other microbial pathogens. This response is typically characterized by increases in the levels of T_H2 (T helper 2) response cytokines interleukin-4 (IL-4) IL-5, IL-9, IL-13 and IL-21 along with activation and expansion of CD4⁺ T_H2 cells, plasma cells secreting IgE, eosinophils, mast cells, basophils and alternatively activated macrophages. The interplay of these cells and molecules leads to the promotion of the inflammation-associated disease that is characterized by human infection with *Angiostrongylus cantonensis*.

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Control and management of slug and snail vectors, with special reference to species in Hawaii (24)

Robert G. Hollingsworth

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Robert.Hollingsworth@ARS.USDA.GOV

Whether being applied by home owners, home gardeners, or commercial vegetable producers, control measures for snails and slugs, which are important vectors of *Angiostrongylus cantonensis*, rely mainly on the use of poison baits, trapping, and habitat manipulation. There are relatively few active ingredients used in poison bait products, and the efficacy of a particular product varies greatly depending on environmental conditions, mollusc species, and attractiveness/acceptability of the bait/poison to the species of interest. Management techniques include changing the environment to reduce soil moisture and eliminating objects or plants that provide shelter and breeding sites. Certain mollusc species are particularly good vectors of *A. cantonensis* by virtue of life history and behavior, for example, a newly invasive semi-slug species that is common on the island of Hawaii.

Extension, brochures, community meetings and follow-up (28)

James R. Hollyer

Agricultural Development in the American Pacific Project, College of Tropical Agriculture and Human Resources, University of Hawaii, 3050 Maile Way, Gilmore 112, Honolulu, Hawaii 96822, U.S.A.
hollyer@hawaii.edu

Getting information on *Angiostrongylus cantonensis* out to commercial farmers, master gardeners and the gardening public is urgent and requires a good understanding of the pathogen and methods of control. At this time, there is no clear information on which commercial water sanitizers can be effective in killing hosts and the pathogen, but two funding proposals are in review. Home and commercial fact sheets are available and may be updated as a result of this workshop. After this workshop is over, and in cooperation with the Hawaii Departments of Health and Agriculture, brief neighbor island meetings will be held to extend appropriate information to the public and farmers.

Potential treatments to aid in recovery of rat lungworm disease patients (12)

Kay Howe

Malama O Puna, 260 E. Lanikaula Street, Hilo, Hawaii 96720, U.S.A.
kehauhowe@gmail.com

A young man was diagnosed in December 2008 with one of the worst cases of rat lungworm disease in Hawaii. He was hospitalized for four months, during three months of which he was in a coma. Nerve damage caused his left eye to turn inward and he was quadriplegic. MRIs showed severe brain damage and hydrocephalitis. In the hospital he became infected with methicillin-resistant *Staphylococcus aureus* (MRSA), *Clostridium difficile*, and pneumonia, which perforated his lung. When he came out of the coma he had severe ataxia, short-term memory loss, double vision and peripheral nerve damage. Emerging studies by neuroscientists treating degenerative brain disorders have identified factors that are key to neurogenesis, including levels of glutathione and the omega-3 fats EPA/DHA. We have found the administration of certain supplements, as well as intra-venous doses of glutathione and vitamin C, all of which address inflammation and free radical damage, to be vital in recovery. Case studies support these treatments.

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Eosinophilic meningitis in a group of people returning from the Caribbean: clinical lessons learned (13)

Stuart Johnson

Loyola University Medical Center and Hines VA Hospital, Building 1, Room C-344, 5000 S. 5th Avenue, Hines, Illinois 60141, U.S.A.
sjohnson@lumc.edu

In April 2000 twelve people developed eosinophilic meningitis following a vacation trip in Jamaica. This outbreak highlighted a previously unrecognized risk of *Angiostrongylus cantonensis* infection in North America and afforded an opportunity to carefully document the incubation period, timing and range of clinical symptoms, and response to treatment. All of the patients recovered, but headache, visual disturbances, and altered cutaneous sensations caused marked morbidity. Resolution of headache correlated with control of intracranial pressure.

Diagnostic considerations and options for clinicians (26)

Stuart Johnson

Loyola University Medical Center and Hines VA Hospital, Building 1, Room C-344, 5000 S. 5th Avenue, Hines, Illinois 60141, U.S.A.
sjohnson@lumc.edu

The April 2000 outbreak of eosinophilic meningitis in a group of American tourists following a visit to Jamaica was recognized on clinical grounds, but serologic confirmation of *Angiostrongylus cantonensis* infection was delayed for months, long after the patients had recovered. The diagnosis would have been markedly delayed or totally missed, had the cases occurred singly and not as part of an outbreak. Variable appearance and timing of eosinophilia in the blood and cerebral spinal fluid (CSF), difficulty in visualizing the parasite in the CSF, and minimal changes on brain scanning made confirmation of the diagnosis difficult. An accessible, rapid diagnostic test would be of great clinical benefit, particularly for diagnosis of isolated cases.

Definitive, intermediate, paratenic, and accidental hosts of *Angiostrongylus cantonensis*, and its molluscan intermediate hosts in Hawaii (2)

Jayne R. Kim

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The life cycle of *Angiostrongylus cantonensis* goes through stages in a definitive host (rats) and intermediate hosts (slugs and snails). Paratenic hosts, in which immature worms are maintained but do not mature, include freshwater shrimp, fish, crabs and other species. Accidental hosts act as alternate pathways for the parasite, but the worms die without reproduction. Ingestion of intermediate and paratenic hosts is the main cause of infection in humans and other accidental hosts. It is therefore imperative to determine which species are vectors so that they can be managed or controlled. Sixteen species of snails and slugs from the Hawaiian Islands were screened for *A. cantonensis*, 13 testing positive. These 13 represented a wide taxonomic range of pulmonate snails and slugs, as well as distantly related operculate snails, suggesting that most gastropods can act as vectors.

The current situation regarding angiostrongyliasis in mainland China (6)

Zhao-Rong Lun

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lsslzr@mail.sysu.edu.cn

Human angiostrongyliasis caused by *Angiostrongylus cantonensis* is still one of the key food-borne parasitic diseases in mainland China. Here I will give an overview of the current situation regarding angiostrongyliasis in mainland China and will summarize the results of work on *A. cantonensis* with animal models in our university. Also, I will discuss the possibility of the next rat lungworm (*Angiostrongylus cantonensis*) workshop, which we hope can be held in Sun Yat-Sen University, Guangzhou, China.

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Taxonomy and transmission dynamics of *Angiostrongylus cantonensis* in *Rattus norvegicus* in Brazil (5)

Arnaldo Maldonado, Jr.

(to be presented by Silvana C. Thiengo)

Instituto Oswaldo Cruz, Av. Brasil 4365, 21045-900 Rio de Janeiro, RJ, Brasil
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Identification of lungworms from Barra do Piraí and São Gonçalo (Rio de Janeiro State, Brazil) was done by comparing morphological and morphometric data from adult *Angiostrongylus cantonensis* obtained from experimental infections with those of worms from Pernambuco (Brazil) and Akita (Japan), and by comparison with published descriptions of worms from Canton, China, and Africa. The morphological bursal characteristics of Barra do Piraí specimens most closely matched specimens from Canton, China, and from Pernambuco, whereas São Gonçalo specimens were closer to *A. cantonensis* from Africa. The presence of particular characters of the caudal bursa and length of the spicules confirms the specimens as *A. cantonensis*. The dynamics of transmission by *Rattus norvegicus* indicate that *A. cantonensis* infection is enzootic among the exotic rat population in Rio de Janeiro. The natural rodent infection rate of 74 % is the second highest ever reported among those of 14 severely endemic regions in the world.

Test development and perspectives for the future of laboratory diagnosis of angiostrongyliasis (18)

Alessandra L. Morassutti

Institute of Biomedical Research, Laboratory of Molecular Parasitology, Pontifícia Universidade Católica do Rio Grande do Sul, Av. Ipiranga, 6681 Predio 12C, Sala 282, Porto Alegre, RS, Brazil
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The 31kDa antigen of crude female worms has been considered as a target for immunodiagnosis of angiostrongyliasis. This talk will focus on recent studies done to ascertain the sensitivity and specificity as well as describe the proteomics and genomics approaches used to characterize this protein. The talk will also briefly address the potential of new diagnostic targets in the excretion-secretion (ES) antigens of *Angiostrongylus cantonensis*.

Brief summary of an angiostrongyliasis case from Hawaii with neurologic sequelae, and a summary of the medical treatment literature (14)

Gerald S. Murphy

Infectious Disease Department, Tripler Army Medical Center, MCHK-DM, 1 Jarrett White Road,
Honolulu, Hawaii 96859, U.S.A.

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This past year we cared for a young man who ate a raw snail and developed altered mental status with cranial nerve palsy, limb weakness and ataxia. He still had neurologic findings three months later. The literature reports that serial lumbar punctures to relieve intracranial pressure appear to be helpful. There is some clinical trial evidence for the benefit of high dose corticosteroid therapy in certain cases. Antihelminthic therapy is controversial.

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Ideas to disseminate knowledge of angiostrongyliasis to clinicians, and ideas for future clinical trials (25)

Gerald S. Murphy

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Some ideas will be offered regarding how information can be disseminated to the medical community, including publications available already, options for publication of the proceedings of this workshop, other useful publications in the general medical literature, websites, press releases, letters to schools and training programs. Some ideas for future clinical trial design, including ways to measure severity, laboratory documentation of infection, and possibilities of newer drugs if any will also be discussed. This presentation is designed mainly to stimulate discussion during the following session.

***Angiostrongylus cantonensis*: epidemiology in the continental United States and Hawaii (11)**

Sarah Park¹ and LeAnne Fox²

¹Hawaii Department of Health, 1250 Punchbowl Street, Room 443, Honolulu, Hawaii 96813,
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²Division of Parasitic Diseases and Malaria, Office of Global Health, Centers for Disease Control
and Prevention, 4770 Buford Highway, NE, MS F-22, Atlanta, Georgia 30341, U.S.A.

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Autochthonous *Angiostrongylus cantonensis* infection has been little recognized in the continental United States with the exception of Louisiana. In contrast, it was recognized in Hawaii in the early 1960s, and the parasite has been considered endemic since. However, infections were rare until late 2004, when a case cluster was noted on the Island of Hawaii. While still uncommon, *A. cantonensis* infection has continued to emerge throughout the state, especially on the Island of Hawaii. Despite increased community awareness, the diagnosis is commonly missed, and the lack of diagnostic tests as well as the challenge of educating clinicians and the public are constant limitations to the prevention and control of this emerging infection.

**Detection of *Angiostrongylus cantonensis* in intermediate, definitive and paratenic hosts
(molecular and other methods) (20)**

Yvonne Qvarnstrom¹ & Alex daSilva²

Building 23, Mailstop D-64, 1600 Clifton Road, Atlanta, Georgia 30329, U.S.A.

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Angiostrongylus cantonensis has been detected in a number of different species of molluscs and other organisms that may serve as potential intermediate or paratenic hosts. This talk will focus on the recent investigations conducted worldwide in this area.

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Angiostrongyliasis in Jamaica: 1994 to present (9)

Ralph Robinson, John Lindo, Cecelia Waugh & Cheridah Todd

Department of Life Sciences, The University of the West Indies, Mona, Kingston 7, Jamaica
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In Jamaica, eosinophilic meningitis (EM) was first reported in 1996 in a middle-aged woman. Interest in *Angiostrongylus cantonensis* was ignited in 2000 following the death of a local boy from infection, and an outbreak of EM among visitors from the U.S.A. a month later. So far, the parasite has been demonstrated in 33 % (n = 437) of wild rats across the island, in five species of molluscs, and in about 20 humans. While KAP (knowledge, attitudes and practices of pertinent people) and laboratory studies point to autochthonous transmission involving contaminated vegetables, the role of paratenic hosts remains uncertain. Development of practical diagnostic tests, and informative epidemiological studies are major goals.

Differential diagnosis of CNS angiostrongyliasis (16)

Kittisak Sawanyawisuth

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Several parasitic infections and other causes need to be differentiated from angiostrongyliasis. *Gnathostoma spinigerum* is the main parasite that may cause production of cerebrospinal fluid eosinophils. Other parasites include *Taenia solium*, *Paragonimus westernmani*, *Toxocara canis*, and *Baylisascaris procyonis*.

Nonindigenous apple snails as hosts of *Angiostrongylus cantonensis* in the southeastern United States (3)

John Teem

Florida Department of Agriculture and Consumer Services, Division of Aquaculture, 1203
Governor's Square Boulevard, 5th Floor, Tallahassee, Florida 32301, U.S.A.
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A survey of nonindigenous apple snail populations in the U.S. Gulf States region suggests that *Pomacea insularum* are a reservoir for *Angiostrongylus cantonensis* and may facilitate the spread of the parasite. Strategies for genetic biocontrol of apple snails are being developed and may be useful in considering approaches to control of snail and slug hosts of *A. cantonensis*.

Angiostrongyliasis in Brazil - an emerging disease, distribution and spread (10)

Silvana C. Thiengo

Instituto Oswaldo Cruz, Av. Brasil 4365, 21045-900 Rio de Janeiro, RJ, Brasil
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Eosinophilic meningitis is considered an emerging disease in Brazil as nine human cases have been reported from south, southeast and northeast regions in the past four years. In almost all of these cases the human infection is due to accidental ingestion of snails, mainly the Giant African snail, *Achatina fulica*, as Brazil is currently experiencing an explosive phase of the invasion of this mollusc. In addition to the current distribution of *A. cantonensis* we will outline our experience in detection of the parasite in samples of molluscs that we have been receiving from public health services all over Brazil over the last six years, as well as what has been done to protect the public.

RAT LUNGWORM DISEASE SCIENTIFIC WORKSHOP - HONOLULU, HAWAII AUGUST 16 - 18, 2011

Angiostrongyliasis in Taiwan (7)

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The major intermediate hosts for *Angiostrongylus cantonensis* in Taiwan are the giant African snail (*Achatina fulica*) and the golden apple snail (*Pomacea canaliculata*). Since the first human infection was reported in Taiwan in 1945, there have been many cases reported, mainly in children, and most of them two to three decades ago. In 1998-1999, we reported two outbreaks of eosinophilic meningitis caused by *Angiostrongylus cantonensis* infection among 17 adult male Thai laborers who had eaten raw golden apple snails. Another outbreak associated with a health drink consisting of raw vegetable juice was reported in 2001. With the improvement of public health, there has been no recent large outbreak in Taiwan.

The discovery of humans in Hawaii infected with *Angiostrongylus cantonensis*, and early epidemiological findings

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In the course of investigating the possible presence of eosinophilic meningitis in Hawaii, it was learned that two patients who had died at the State Mental Hospital on Oahu in December 1959 and January 1960 had eosinophilic meningoencephalitis. The preserved brain of one patient yielded a number of young adult nematodes identified as *Angiostrongylus cantonensis*. Was this parasite the cause of the thousands of cases of eosinophilic meningitis recently reported in French Polynesia?

Laboratory algorithms for diagnosis of angiostrongyliasis (17)

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Parasitological, molecular and serological methods that are presently available for laboratory diagnosis of angiostrongyliasis will be presented, with a proposed algorithm for ordering tests and interpreting results. The presentation will also briefly address the regulatory framework for clinical diagnostic testing so that laboratories can remain compliant with federal and state regulations.

Invasion, spread, detrimental effects and control of the snail *Pomacea canaliculata*, an important vector of *Angiostrongylus cantonensis* in China (23)

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Pomacea canaliculata was introduced to China in the early 1980s from Argentina, its native region, for the purpose of aquaculture. Due to the lack of natural enemies and its tolerance of a wide range of environmental variables, both the population size and distribution have dramatically increased and it has become a harmful species to agriculture and other native species in many areas of China. The snail was also found to act as an intermediate host of *Angiostrongylus cantonensis* and has been implicated in transfer of the parasite to people, resulting in angiostrongyliasis. Therefore, efforts to prevent its spread and population expansion were initiated many years ago, including the use of natural enemies to control the snail.