THE SPREAD OF ANGIOSTRONGYLIASIS: THE GLOBETROTTING RAT LUNGWORM

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Abstract. *Angiostrongylus cantonensis* is recognized as one of the major causes of eosinophilic meningitis. The dissemination at one time was believed to be by the spread of the snail *Achatina fulica*. Indeed this intermediate host may have been involved with the early spread in Asia; however, the spread of the parasite to other places probably has been due to the movement of rats. Public health authorities should be made aware that angiostrongyliasis might become a problem.

THE SPREAD OF ANGIOSTRONGYLIASIS

Angiostrongylus cantonensis is recognized as one of the major causes of eosinophilic meningitis. The nematode was first reported from China in 1935 (Chen, 1935) and the first human infection was from Taiwan in 1945 (Nomura and Lin, 1945). Eosinophilic meningitis was reported occurring in the Pacific Islands for a number of years (Bailey, 1948), but the etiology was not known until the parasite was found in the brain of a mental patient in Hawaii (Rosen *et al*, 1962). This was followed by reports of the diseases in Southeast Asia and the Pacific Basin. The parasitosis is now being reported worldwide (Cross, 2004).

In the rat definitive host, the parasite is located in the pulmonary arteries. Eggs produced by the female worms hatch, and the larvae migrate to the intestine and pass in the feces. Molluscan intermediate host acquire the infection, and the larvae develop into the infective third stage. When the intermediate molluscan host is ingested by rats, the larvae are digested out of the tissues, migrate to the central nervous system, develop into young adults that migrate to the pulmonary arteries, and become sexually mature. When humans ingest an infected intermediate or paratenic host, the released larvae migrate to the CNS and cause disease. The parasites usually die in the CNS; however, occasionally they migrate to the eye and rarely to the lung where they can become sexually mature (Cross, 1987).

A number of *Rattus* and *Bandicota* species are known definitive host of *A. cantonensis*. *Rattus norvegicus* and *R. rattus* are the rats most commonly infected internationally, followed by regional rats such as *R. argentiventer, R. exulans, R. jalorensis*, and *R. rattus alexandrinus* (Bhaibulaya, 1982).

Various species of mollusc serve as an intermediate host. The giant African land snail, *Achatina fulica*, is considered a major source of infection in Asia and the Pacific Basin, and many other terrestrial and aquatic molluscan species can also be intermediate hosts. Species of aquatic snails (Ampullariidae) imported from South America are evolving as important host in China and Taiwan. Other snails such as *Pila* spp, *Bradybaena similaris*, and *Subulina octona* and slugs such as *Vaginulus plebeius*, *Veronicella leydigi* and *Deroceras laeve* are also known vectors of the parasite. A great number of other mollusc species have been shown experimentally to be susceptible to infection (Richards and Merritt, 1967) and aquatic snail *Biomphalaria glabrata* has been used in the laboratory to maintain the life cycle (Alicata and Jindrak, 1970; Bhaibulaya, 1982). Other animal species are known as paratenic or transport host for the parasite. The land planarians are accidental hosts; aquatic and terrestrial crabs, prawns, and shrimps have been associated with epidemics. Frogs, toads, and monitor lizards are paratenic host and

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are reported to be sources of human infection.

The spread of *A. cantonensis* throughout the world initially was attributed to the dissemination of the great African snail from Madagascar to Mauritius, and on to India, Sri Lanka, Malaysia, China, Taiwan, Southeast Asia, the Pacific Islands, and Australia. The snail, along with the parasite, may have been transported around the Pan-Pacific area during and after World War II (Kliks and Palumbo, 1992). Mead (1961) has depicted the spread with dates of dispersal of the *A. fulica* in the nineteenth century. Alicata and Jindrak (1970) subsequently speculated that the spread of *A. cantonensis* was by the snail as it was transported to various parts of the world (Fig 1).

Since 1962, angiostrongyliasis has been reported primarily from Asia and the Pacific Basin. The disease was later reported from Africa in 1970 (Kliks and Palumbo, 1992). The first report of the parasite and the disease in the Western Hemisphere was from Cuba (Pascual *et al*, 1981; Aguiar *et al*, 1981). Rats and local molluscs were found infected. The parasite was later reported from the Dominican Republic, Haiti, Jamaica, Puerto Rico, and the Bahamas. The disease demonstrated serologically was also reported from Guadalupe (Cross, 2004). *Rattus* spp and local molluscs have also been found infected in the Caribbean Islands. *Achatina fulica*, however, has not been implicated. The means of transmission of the parasite is not known in the islands, and infection in humans is believed to be due to the accidental ingestion of an intermediate or paratenic host.

The parasite was not reported in rats or molluscs in the United States until Campbell and Little (1988) found rats in New Orleans, Louisiana, infected. They did not find infected molluscs but were able experimentally to infect local snails with the parasite. During the 1960s and 1970s, rats in New Orleans were examined routinely for parasitic infection, but *A. cantonensis* was never found. The authors speculated that infected rats arrived in New Orleans by ship and introduced the nematode to the area in the 1980s.

The first report of possible spread *A. cantonensis* in the Americas was a report of fatal meningoencephalitis in a howler monkey in the Audubon Park and Zoological Gardens in New Orleans (Gardiner *et al*, 1990). The same paper reported infection in a white handed gibbon in the Ardastra Gardens and Zoo, Nassau, Bahamas. In 1999, Aguilar *et al* (1999) reported angiostrongyliasis in seven other monkeys

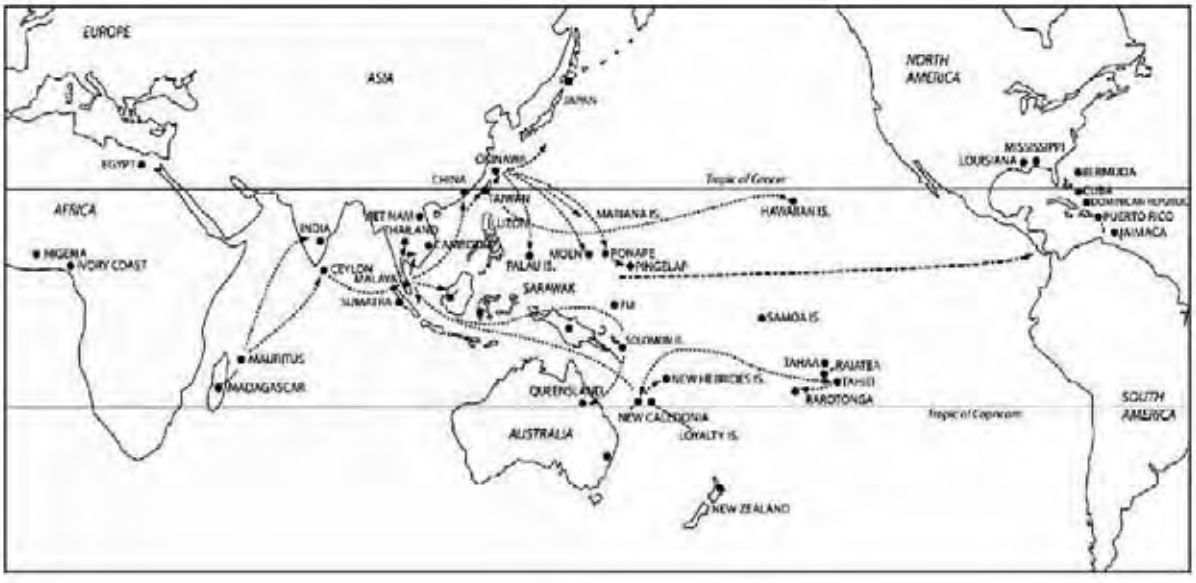

Fig 1- Geographical distribution of murine and human angiostrongyiasis in the tropical and subtropical regions. Arrows indicate theoretical easterly migration of the parasite. (Modified from Alicata and Jindrak, 1970).

in the New Orleans Zoo. The parasite was also found in snails and slugs after the second report in the New Orleans Zoo. A human case of angiostrongyliasis was reported from an 11 year old boy in New Orleans who acquired the infection by ingesting a snail on a dare from his sister (New *et al*, 1995). A miniature horse from Picayune, Mississippi, was reported infected with the parasite and at the same time *R. norvegicus* trapped in Baton Rouge, Louisiana, was found infected (Costa *et al*, 2000). In 2002, a lemur from the New Iberia Louisiana Zoo was found with a CNS infection, and infection was found in a wood rat and possums from Baton Rouge, Louisiana (Kim *et al*, 2002). A second human infection was reported from Louisiana in a man who ate two raw legs from a green tree frog on a dare (Cuneo *et al*, 2006). Further evidence of the spread of *A. cantonensis* in the United States was a report in a white-handed gibbon in the Miami Metrozoo in Miami (Duffy *et al*, 2004). An epidemic of eosinophilic meningitis caused by *A. cantonensis* was reported in 12 medical students who ate a common meal of Caesar salad in Jamaica (Slom *et al*, 2002). Symptoms were experienced few days after returning to the United States and serological diagnoses made. There have been reports of finding the parasite in *Rattus* spp and snails in Jamaica, and a fatal case was documented in a young male with worms found in the brain and lung (Lindo *et al*, 2002).

COMMENTS

Angiostrongylus cantonensis and eosinophilic meningitis, due to infection with the nematode, have now been reported globally. The dissemination at one time was believed to be by the spread of the snail, *Achatina fulica*. Indeed this intermediate host may have been involved with the early spread in Asia; however, the spread of the parasite to other places probably has been due to the movement of rats. Rats easily gain access to ships and it is likely that infected rats "jump ship" at various ports. Many species of snails are susceptible to infection and rats passing larvae in the feces can easily be picked up by local snails and slugs, thus is establishing the parasite (Kliks and Palumbo, 1992). Cargo being shipped from endemic areas may harbor rats and molluscs, and drug trafficking may have been involved. Without question, the parasite will spread and propagate, especially in the warmer parts of the world. The southern United States should be concerned. The intermediate, definitive, and paratenic hosts are available and are susceptible to infection. Two human infections have been reported from Louisiana and Public Health authorities should be made aware that angiostrongyliasis might become a problem.

REFERENCES

Aguilar RF, Topham K, Heatley JJ, *et al*. Neural angiostrongyliasis in non-human primates: diagnosis, treatment and control of an outbreak in Southern Louisiana. In: Proceedings of the American Association of Zoo Veterinarians, 1999:272-6.

Aguiar PH, Morena P, Pascual J. First record of *Angiostrongylus cantonensis* in Cuba. *Am J Trop Med Hyg* 1981;30:960-2.

Alicata JE, Jindrak K. Angiostrongylosis in the Pacific and Southeast Asia. Springfield, IL: Charles C Thomas, 1970.

Bailey CA. An epidemic of eosinophilic meningitis, a previously undescribed disease occurring on Ponape, Eastern Carolines. Bethesda: Naval Medical Research Institute, Proj NM005007, 1948;Report No 7:1-32.

Bhaibulaya, M. Angiostrongylosis. In: Steele JA, ed. CRC handbook series in zoonosis. Boca Raton, FL: CRC Press, 1982:25-36.

Campbell BC, Little MD. The findings of *Angiostrongylus cantonensis* in rats in New Orleans. *Am J Trop Med Hyg* 1988;38:568-73.

Chen HT. [Un nouveau nématode pulmonaire, *Pulmonema cantonensis* n.g., n. sp. des rats de Canton]. *Ann Parasitol* 1935;13:312-7.

Costa LRR, McClure JJ, Snider TG, Stewart TB. Verminous meningoencephalomyelitis by *Angiostrongylus (Parastrongylus) cantonensis* in an American miniature horse. *Equine Vet Educ* 2000;12:2-6.

Cross JH. Public health importance of *Angiostrongylus cantonensis* and its relatives. *Parasitol Today* 1987;3:367-9.

Cross JH. Iterant *Angiostrongylus (Parastrongyliasis) cantonensis*. In: Proceedings of the European Multicolloqum on Parasitology, Valencia, Spain, 2004:165-74.

Cuneo P, Clement S, Sokol T. Eosinophilic meningitis and angiostrongylus cantonensis. *Louisiana Morbid Rep* 2006;17:1.

Duffy MS, Miller CL, Kinsella JM, deLahunta A. *Parastrongylus cantonensis* in a non-human primate, Florida. *Emerg Infect Dis* 2004;10: 2207-10.

Gardiner CH, Wells S, Gutter AE, *et al*. Eosinophilic meningoencephalitis due to *Angiostrongylus cantonensis* as the cause of death in captive non-human primates. *Am J Trop Med Hyg* 1990;42:70-4.

Kim DY, Stewart TB, Bauer BW, Mitchell M. *Parastrongylus* (*Angiostrongylus*) *cantonensis* now endemic in Louisiana wildlife. *J Parasitol* 2002;88:1024-6.

Kliks MM, Palumbo NF. Eosinophilic meningitis beyond the Pacific basin: the global dispersion of a peridomestic zoonosis caused by *Angiostrongylus cantonensis*, the nematode lungworm of rats. *Soc Sci Med* 1992;34:199-212.

Lindo JF, Waugh C, Hall J, *et al*. Enzootic *Angiostrongylus cantonensis* in rats and snails after an outbreak of human eosinophilic meningitis in Jamaica. *Emerg Infect Dis* 2002;8:324-6.

Mead AR. The great African snail: a problem of economic malacology. Chicago, IL: University Chicago Press, 1961:257.

New D, Little MD, Cross JH. *Angiostrongylus cantonensis* infection from eating raw snails. *N Engl J Med* 1995;332:1105-6.

Nomura S, Lin PH. First case report of human infection with *Haemostrongylus ratti Yokogawa*. *Taiwan no Ikai* 1945;3:589-92 (in Japanese).

Pascual JE, Bouli RP, Aguiar H. Eosinophilic meningoencephalitis in Cuba, caused by *Angiostrongylus cantonensis*. *Am J Trop Med Hyg* 1981;30:960-2.

Richards CS, Merritt JW. Studies on *Angiostrongylus cantonensis* in molluscan intermediate hosts. *J Parasitol* 1967;53: 382-8.

Rosen L, Chapell R, Lacquer GL, Wallace GD, Weinstein PP. Eosinophilic meningoencephalitis caused by metastrongylid lungworm of rats. *JAMA* 1962;179:620-4.

Slom TJ, Cortese MM, Gerber SI, *et al*. An outbreak of eosinophilic meningitis caused by *Angiostrongylus cantonensis* in travelers returning from the Caribbean. *N Engl J Med* 2002;346:668-75.