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The potential significance to human health associated with the establishment of the snail *Melanoides tuberculata* in New Zealand

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Abstract

The thiarid *Melanoides tuberculata* (Müller, 1774) (Gastropoda: Prosobranchia: Thiaridae) is considered to be invasive and have become established in numerous countries outside its native range. This species was discovered in the wild for the first time in New Zealand in 2001, when a population was found in a geothermally warmed stream at Golden Springs near Taupo. *M. tuberculata* is of human health significance as the intermediate host of a number of trematode parasites. Uncertainties hinder an accurate assessment of the risks to human health occasioned by this species in New Zealand, but it is theoretically possible that a number of parasites could become established in this country in association with *M. tuberculata*. However, their distribution would be potentially limited, as *M. tuberculata* is unlikely to find suitable habitats in New Zealand outside certain geothermally warmed water habitats.

The thiarid snail *Melanoides tuberculata* (Müller, 1774) (Gastropoda: Prosobranchia: Thiaridae) (Figure 1) was found in the wild for the first time in New Zealand in 2001.[1] A population was described from a geothermally warmed stream at Golden Springs near Taupo, and its introduction is believed to have been the result of one or more releases from tropical aquaria, although the timing of release is uncertain.[1] Its current distribution in New Zealand is unknown.

MAF Biosecurity New Zealand recently carried out a risk assessment on the possible impacts associated with the establishment of *M. tuberculata* in New Zealand. This article discusses its potential significance to human health.

Species invasiveness and environmental suitability of New Zealand

M. tuberculata is a subtropical/tropical species, which has been introduced (both accidentally and intentionally) to several countries. Its original native range seems uncertain but nonetheless wide, including parts of Africa, Mediterranean, Asia, and Pacific Islands[2,3] It has also become established in several other countries.[4–8]

The success of *M. tuberculata* in new locations seems to be facilitated by biological characteristics such as parthenogenicity and viviparous juveniles.[9] Its biology and the outcomes of previous introductions to other countries indicate that *M. tuberculata* is likely to establish successfully if introduced to areas with suitable habitat.

Figure 1. ***Melanoides tuberculata***

Photo courtesy of Alex Kawazaki (alexkawazaki@uol.com.br)

M. tuberculata has also been used as a biological control agent for snails that are intermediate hosts of trematodes that cause serious human disease.[10–12] In Brazil and the Caribbean, for example, the establishment of *M. tuberculata* has reportedly resulted in the reduction and even disappearance of populations of the planorbid snails *Biomophalaria glabrata* and *B. straminea*.[8]

Field observations show that *M. tuberculata* is able to reach and maintain high densities in permanent and stable habitats. Indeed, up to 37,500 specimens/m^2 have been recorded in estuarine areas of Florida.[4] The high densities and competitive success are thought to be linked to the comparatively low intrinsic rate of natural increase and long generation times observed in other snails, such as planorbids.[13]

Information on the environmental requirements for *M. tuberculata* is available from several countries. The literature discusses the species requirements in regards to substrate,[1,5,14] and water temperature,[1,15–17] depth,[14,18] and salinity.[4]

Toy[19] concluded that the available evidence suggests that *M. tuberculata* would be unlikely to survive the winter even in Northland watercourses. However, *M. tuberculata* has been reported to hibernate during the colder months in Israel.[20] It is unknown whether the New Zealand population would be able to hibernate, which would probably allow it to withstand lower water temperatures during winter.

Nonetheless, given the geographically discrete nature of geothermally warmed water habitats, it is unlikely that snails would spread to new locations in New Zealand unassisted.[19] However, experiments have shown that wildfowl can transport small snails (less than 3 mm) to new locations,[21] and gulls, swans, ducks, and cormorants have been reported roosting and feeding in geothermal hot springs at Lake Rotorua.[22]

Snails and their egg masses can also be transferred in mud or vegetation attached to mammals.[23] Human-assisted dispersal on fomites is therefore a possible pathway for its spread. *M. tuberculata* appears to be able to resist desiccation for several days,[7] and thus would likely survive transfer to new habitats.

Human health significance

M. tuberculata is an intermediate host of a number of trematode parasites such as: *Paragonimus kellicotti*;[24,25] the Chinese liver fluke *Clonorchis sinensis*, and the Oriental lung fluke *Paragonimus westermani*;[8,26] the rat lung-worm *Angiostrongylus cantonensis*;[27,28] *Loxogenoides bicolor*, *Transversotrema laruei*, and *Stictodora tridactyla*;[29] *Gastrodiscus aegyptiacus*;[30] Oriental eye-fluke *Philophthalmus gralli*;[16,31,32] *P. distomatosa*;[33] *Haplorchis pumilio*;[32] *Haplorchis* sp.;[34] *Centrocestus formosanus*;[11,32,35] and *Centrocestus* sp.[34,36]

M. tuberculata is considered to be of medical significance as most of the above cited parasites can affect humans. Although there can be considerable seasonal variation in the intensity of parasitism in these snails, the incidence of *M. tuberculata* with trematode parasites has been recorded to be as high as 92%.[16] It should be noted, however, that the majority of these parasites require the occurrence of first and second intermediate hosts.[26] In such cases, apart from possible environmental constraints, the establishment of a parasitic cycle in New Zealand could be hindered by the absence of one of its intermediate hosts.

Nonetheless, the establishment of *M. tuberculata* in warm water habitats is of potential concern from a public health perspective. Under such warmer conditions it may be possible for exotic parasites to become established in association with *M. tuberculata*. There are examples overseas where the separate introductions of a parasite and its snail host have lead to the establishment of the cycle of parasitic diseases in humans and other animals.[11]

The possible role of *M. tuberculata* as an introduced species leading to new parasitic cycles in humans in invaded areas was previously recognised.[35] This could be the case in New Zealand, especially since geothermally warmed water habitats are likely to be a particular attraction to incoming tourists and foreign students, some of which could arrive in New Zealand infected by parasites, such as the Chinese liver fluke *Clonorchis sinensis*.

C. sinensis is one of the parasites recorded for example in the stool samples of refugees in New Zealand.[37] This organism is shed in the faeces of infected persons, and most infected individuals have few symptoms.[38] This parasite is widespread in Southeast Asia, including China.[39] In Taiwan, for example, prevalence of *C. sinensis* infection in humans varies, but in endemic areas it has been found to be as high as 52%,[40] and just over 7% countrywide,[41] but an endemic area in Vietnam had an infection rate among people of 73%.[42]

M. tuberculata is the first intermediate host of the parasite,[26] with dozens of freshwater fish species identified as second intermediate hosts, prior to infection of the definitive hosts (e.g. humans).[39,41,42] Since clonorchiasis is primarily acquired through the ingestion of raw or inadequately cooked freshwater fish,[26,40] the likelihood of human infection in New Zealand could be considered low (in contrast for instance to Southeast Asia). However, the likelihood of infection may be significantly compounded by utensil contamination with metacercariae, which may be an important route for *Clonorchis* infection in humans.[39,43]

Other trematodes that may be introduced to New Zealand are *Paragonimus kellicotti* and *P. westermani*, both of which cause human infections,[42] although these are primarily parasites of other mammals such as cats and dogs. *Paragonimus* species require a crustacean (crab or crayfish) as a second intermediate host to complete its cycle, which when eaten raw or improperly cooked lead to human cases of paragonimiasis.[24,26] As with *Clonorchis*, the use of contaminated kitchen utensils could be an important route leading to infection in humans. *Paragonimus* spp. could be introduced into New Zealand in the stools of an infected person arriving in the country, and it seems that human infection may persist for as long as 20 years.[44]

Haplorchis spp.[34] and *Centrocestus formosanus*[11,32,35] also utilise *M. tuberculata* as their first intermediate host, with a number of fish species being second intermediate hosts.[45] As with other trematodes, human infection occurs via the consumption of raw or improperly cooked fish, although the use of contaminated kitchen utensils may also be a significant route for human infection.

M. tuberculata is also an intermediate host of the rat lung-worm *Angiostrongylus cantonensis*,[27] a parasite that causes eosinophilic meningitis in humans,[28] usually a self-limiting disease,[46] which may occasionally lead to serious complications and consequent death.[47]

Apart from the snail intermediate hosts, several animals such as crabs, shrimps/prawns, fish, planaria, frogs, and toads are also known to be paratenic or carrier hosts.[28,48] As for the other human parasites associated with *M. turberculata*, human infection with *A. cantonensis* occurs through ingestion of raw or inadequately cooked hosts.[48] However, food contaminated with the infective third stage larvae may also lead to infection.[28,46] An outbreak in Jamaica, for example, is believed to have occurred as a result of consumption of contaminated vegetables.[49]

It is possible that food plants, such as watercress, may be cultivated in unhygienic locations where infected snails are present, leading to human infection.[42] In addition, it has been suggested that human infection is also acquired by ingestion of water contaminated with mucus containing *A. cantonensis* larvae secreted by the mollusc.[46] Furthermore, it seems that infection with *A. cantonensis* can occur on children who have been playing with host snails.[39,48]

Although there seems to be no comprehensive data on the distribution of *A. cantonensis*,[28] this species is prevalent in the Pacific Islands and Southeast Asia,[48] and it is also present in Australia.[46] However, since humans are dead end hosts for the parasite, *A. cantonensis* would not be spread into the environment directly from humans, but it would have to arrive in New Zealand via other pathways.

M. tuberculata is an intermediate host of the eye flukes *Philophthalmus* spp.,[31–33] which are primarily parasites of birds.[50] The life cycle of this parasite involves the snail intermediate host and birds as the definite hosts,[51] but *Philophthalmus* spp. may occasionally infect humans and other animals.[50,52] Human infection by this parasite may occur via direct contact with the eye (e.g. with cercariae in the water column) or by the oral route (e.g. ingestion of cercariae on contaminated raw vegetables).[32,50,51] On avian hosts, *Philophthalmus* eggs or miracidia are eliminated by direct contact of the eyes, nasal or oral passages of the host with water,[51] and the same pattern may apply to human hosts.

A *Philophthalmus* spp. has been previously recorded from a gull in New Zealand and a marine mollusc,[53] and the presence of *M. tuberculata* may allow for wider establishment of this parasite, and consequent infection of definitive hosts, mainly avian but possibly human.

It is relevant to point out that *M. tuberculata* has been successfully introduced as a biocontrol agent against the snail hosts of the human intestinal parasite *Schistosoma mansoni*.[10-12] It seems that in areas where the human health impacts of *S. mansoni* are extensive, the potential negative consequences of the introduction of other comparatively minor parasites in association with *M. tuberculata* are disregarded.

In New Zealand, indigenously acquired cases of human infection with snail-associated parasites do exist (e.g. *Cercaria longicauda* which causes 'swimmers' itch')[54-56] but are rare. Therefore, the establishment of parasites considered to be minor overseas may be of considerably greater magnitude in this country. In addition, under a global warming scenario Poulin predicts that "small increases in air and water temperature forecast by many climate models will not only influence the geographical distribution of some diseases *[caused by trematode parasites]*, but may also promote the proliferation of their infective stages in many ecosystems".[57]

Although the likelihood of introduction and establishment of some of the human parasites hosted by *M. tuberculata* is probably low, it is not known whether any of the above are already present in the country. According to Duggan,[1] direct release from an aquarium was the most likely source of introduction of this snail into the wild, a species that appears to be popular in the New Zealand aquarium trade. It is therefore possible that some of these parasites of human significance may already be present in aquaria in New Zealand; however, due to other factors (such as the absence of second intermediary hosts) we are yet to observe cases of these parasitic diseases in this country.

It is also unclear whether the second intermediate hosts for a number of these human parasites associated with *M. tuberculata* are present in New Zealand. However, as observed for example for *Centrocestus formosanus* in Mexico,[58] trematode parasites may utilise new hosts once introduced to new habitats.

Conclusions

There are considerable uncertainties regarding the presence of *M. tuberculata* in this country, and consequently its potential human health impacts, mainly:

- There is currently no available information on the likely distribution of the species in New Zealand.
- It is not known whether the population in New Zealand is able to hibernate in the wild, and the extent of suitable habitat in the country is uncertain.
- It is not known which parasites occur within the New Zealand aquarium or wild populations of *M. tuberculata.*
- It is unclear whether the second intermediate hosts for many of the parasites associated with *M. tuberculata* are present in New Zealand.

- It is difficult to predict the likelihood of the trematodes parasites arriving in New Zealand in the human pathway and subsequent being transferred to habitats where *M. tuberculata* is present.

Therefore, it is difficult to accurately assess the likely human health impacts associated with the presence of *M. tuberculata* in New Zealand. Although the species would likely spread to most other suitable habitats in the country, only restricted parts of geothermally warmed water habitats would seem to provide suitable conditions for its establishment.

Nonetheless, it is theoretically possible that some exotic trematodes could become established in this country utilising this snail as an intermediate host, and subsequently leading to cases of human infection.

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