TAXONOMY OF *TRICHINELLA* AND THE EPIDEMIOLOGY OF INFECTION IN THE SOUTHEAST ASIA AND AUSTRALIAN REGIONS

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Abstract. Seven species belonging to the *Trichinella* genus (five with encapsulated larvae and two with non-encapsulated larvae in host muscles) and three additional genotypes have been described to date: *T. spiralis* (genotype T1), a cosmopolitan species with a high infectivity to swine and rats; *T. nativa* (T2), etiological agent of sylvatic trichinellosis in arctic and subarctic areas of the Holarctic region, and its related genotype (*Trichinella* T6), detected in Alaska, Idaho, Montana, Pennsylvania, Wyoming, and Ontario.; *T. britovi* (T3), etiological agent of sylvatic trichinellosis in temperate areas of Europe and Asia, and its related genotypes *Trichinella* T9 in Japan and *Trichinella* T8 in South Africa and Namibia; *T. murrelli* (T5), etiological agent of sylvatic trichinellosis in temperate areas of the USA; *T. nelsoni* (T7), etiological agent of sylvatic trichinellosis in Africa south of the Sahara; *T. pseudospiralis* (T4), a non-encapsulated cosmopolitan species infecting both mammals and birds; and *T. papuae* (T10), a recently discovered non-encapsulated species in sylvatic swine of Papua New Guinea. In the Southeast Asia and Australian regions, *T. spiralis*, *T. pseudospiralis* and *T. papuae* have been detected in sylvatic and domestic animals and in humans. A focus of human trichinellosis due to *T. papuae* was recently discovered in Papua New Guinea, with a prevalence of 28.9%. Trichinellosis has also been documented in domestic animals and/or humans in Cambodia, Indonesia (Bali and Sumatra), Lao PDR, Malaysia, Myanmar, Thailand, and New Zealand, and in wildlife of Tasmania.

INTRODUCTION

In the past 10 years, the vast amount of epidemiological data obtained on parasites belonging to the genus *Trichinella* and the high number of isolates collected throughout the world have allowed the taxonomy and epidemiological knowledge of this parasite to be continuously updated. To date, seven species (five with encapsulated larvae and two with non-encapsulated larvae in host muscles) and three additional genotypes have been described (Pozio *et al*, 1992,1999; Nagano *et al*, 1999; Pozio and La Rosa, 2000).

With regard to the Southeast Asia and Australian regions, information on the epidemiology of trichinellosis in humans and animals is insufficient. Reports are either very old or very recent; consequently, the available information is not uniform in terms of space or time. Furthermore, it has been shown that the epidemiology of trichinellosis in domestic animals and humans can worsen over a few years, as has occurred in the past decade in central-eastern European countries, as a result of the breakdown of government veterinary services and state farms, economic problems and war.

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TAXONOMY

The following taxonomic scheme of the *Trichinella* genus is the result of a series of morphological, biological, biochemical, and molecular studies carried out in the past 15 years on approximately 1,000 isolates from domestic and sylvatic animals and from humans collected in the Palearctic (Europe, Asia, and North Africa), Nearctic (North America), Neotropic (Central and South America), Ethiopic (Africa south of the Sahara), and Australian (Australia, New Zealand, Papua New Guinea, Tasmania, etc) regions.

Two main groups of species have been distinguished in the genus: those species with a collagen capsule around the nurse cell-larva complex (encapsulated species) and those without a capsule (non-encapsulated species) (Pozio *et al*, 2001).

Encapsulated species

1) *Trichinella spiralis* (genotype T1): the best known species, with a high infectivity to swine and rats, whose distribution is cosmopolitan because of passive introduction with domestic pigs and synanthropic rats. Most infections in humans, domestic pigs, and synanthropic rats are related to this pathogen. This species has also been detected in wildlife in temperate regions. Larvae of this species do not survive freezing in host muscles. Improper human behavior in swine-breeding, horse-breeding, and hunting practices can favor an increase in the prevalence of infection of this parasite both in domestic and sylvatic animals.

2) *Trichinella nativa* (genotype T2): etiological agent of sylvatic trichinellosis in arctic and subarctic areas of the Holarctic region (Europe, Asia, and North America), and its related genotype (*Trichinella* T6) detected in Alaska, Idaho, Montana, Pennsylvania, Wyoming, and Ontario. The main reservoirs are carnivores (wolf, black and grizzly bears, mountain lion, lynx, fox, and raccoon dog, among others), in which muscle larvae can survive freezing for up to 5 years. Human infections with both genotypes T2 and T6 are mainly related to the consumption of raw or undercooked game. Domestic and sylvatic swine are resistant to this parasite (Kapel and Gamble, 2000), although there has been one report of *T. nativa* in a domestic pig from northern China and in two wild boars from Estonia (Pozio and Kapel, 1999).

3) *Trichinella britovi* (genotype T3): etiological agent of sylvatic trichinellosis in temperate areas of Europe and Asia. The main reservoirs are wolf, fox, raccoon dog, jackal, and bear, among other carnivores. This parasite can infect domestic and sylvatic swine, though the reproductive capacity index in these animals is lower than that of *T. spiralis* (Kapel and Gamble, 2000). The isolates of *T. britovi* of Japan are considered as constituting a separate genotype (*Trichinella* T9) (Nagano *et al*, 1999), as are those from South Africa and Namibia (*Trichinella* T8), which were probably imported from Europe during the European colonization in the 17th century (La Rosa and Pozio, 2000).

4) *Trichinella murrelli* (genotype T5): etiological agent of sylvatic trichinellosis in temperate areas of the Nearctic region (Connecticut, Georgia, Illinois, Indiana, New Mexico, Pennsylvania, and Texas). The main reservoirs are black bear, raccoon, coyote, red fox, and bob cat. Domestic swine are resistant to this parasite (Kapel and Gamble, 2000). Humans acquire *T. murrelli* by eating game, though a human outbreak for the consumption of horse meat has been documented (Pozio and La Rosa, 2000).

5) *Trichinella nelsoni* (genotype T7): etiological agent of sylvatic trichinellosis in Africa south of the Sahara (Kenya, Tanzania, and South Africa) (La Rosa and Pozio, 2000). The main reservoir is the spotted hyena, though other carnivores living in protected areas have been found to be infected. In total, less than 100 human infections have been documented in Ethiopia, Kenya, Tanzania, and Senegal (Pozio *et al*, 1997).

Non-encapsulated species

1) *Trichinella pseudospiralis* (genotype T4): found in both mammals and birds. Three different populations of *T. pseudospiralis* have been identified in the Nearctic, Palearctic and Australian regions (Zarlenga *et al*, 1996). Human infections have been documented in Tasmania, Thailand, Kamchatka, and France for the consumption of domestic or sylvatic swine. This parasite has been documented as an etiological agent of domestic trichinellosis in Kamchatka (Britov, 1997).

Table 1
Documented infections with *Trichinella* in animals and humans of Southeast Asia and Australian countries.

Country	*Trichinella* infections		
	humans	domestic animals	sylvatic animals
Australia			
Tasmania	n.i.[a]	n.i.	5 marsupial and 2 bird species
Cambodia	yes	n.i.	n.i.
Indonesia			
Bali	yes	n.i.	n.i.
Sumatra	n.i.	pigs[c]	n.i.
Lao PDR	yes[c]	n.i.	n.i.
Malaysia	yes[b]	n.i.	n.i.
Myanmar	n.i.	pigs	n.i.
New Zealand	yes	pigs	rats
Papua New Guinea	yes	pigs	wild pigs
Thailand	yes	pigs, dogs	wild boars, black bear, jackal, rats

[a] n.i.= no information
[b] Infections acquired in Malaysia but diagnosed in Singapore
[c] Reports dating back more than 20 years

2) *Trichinella papuae* (genotype T10): the most recently discovered species, detected in sylvatic swine of Papua New Guinea (Pozio *et al*, 1999). Infections in humans have been recently documented.

EPIDEMIOLOGY IN THE SOUTHEAST ASIA AND AUSTRALIAN REGIONS

In Thailand, *T. spiralis* infection occurs frequently in domestic animals (pigs and dogs) and humans (more than 6,000 infections since 1962, with 1.6% mortality); they sometimes occur in synanthropic rats and wild pigs and have been reported in a Himalayan bear (Khamboonruang, 1990). A human outbreak for the consumption of pork from a wild pig was reported to have been caused by *T. pseudospiralis* (Jongwutives *et al*, 1997). According to Watt *et al* (2000), approximately 200-600 human infections occur annually in northern Thailand during communal feasts celebrating the Thai New Year, though few of them have been documented.

There are very few reports of trichinellosis in other countries of Southeast Asia. In Indonesia, though most people are Muslims and do not eat pork, the island of Bali is one of the few areas of the country where the majority of people are Hindus. Trichinellosis has been documented in 19.5% of young people from Bali by serology (Chomel *et al*, 1993) and in domestic swine from Tapanuli, the northern region of the island of Sumatra, where local customs of cooking or roasting meat greatly hinder the transmission to humans (Holtz, 1962; 1979). The etiological agent of trichinellosis in domestic pigs from Bali and Sumatra has never actually been identified, although it had been reported to be *T. spiralis*. In Malaysia, an outbreak of trichinellosis occurred in Singapore among 84 students and teachers who had visited a neighboring Malaysian island in 1998 (Kurup *et al*, 2000). In Lao PDR, a human outbreak of trichinellosis involving 51 persons who had consumed pork was documented in 1975 (Sicard *et al*, 1976). Specific anti-*Trichinella* IgG were detected by ELISA in 7.1% (13/184) of serum samples from asymptomatic persons living in a remote village of Cambodia (unpublished data). Trichinellosis is also present in domestic pigs from Myanmar (Watt *et al*, 2000), but the prevalence of infection in this animal species is unknown. Recently, a focus of trichinellosis in humans was discovered in Bensbach, a remote area of Western Papua New Guinea where *T. papuae* was detected in wild pigs. The serological prevalence of infection, detected by ELISA using a synthetic tyvelose antigen, in persons living in six villages in this area was 28.9% (28/97). All infected persons were asymptomatic; however, the prevalence of eosinophilia was higher in serologically positive persons than in those who were serologically negative.

In the Australian region, animal trichinellosis caused by *T. pseudospiralis* was documented in 5 species of marsupials and 2 species of birds from Tasmanian wildlife (Obendorf *et al*, 1990; Obendorf and Clerk, 1992). Synanthropic rats and domestic pigs have been sporadically found to be infected with *T. spiralis* in New Zealand (Cairns, 1966; Buncic, 1997), where the parasite was imported from Europe. One infection with *T. pseudospiralis* was documented in a woman of New Zealand who had visited Tasmania (Andrews *et al*, 1995).

In Southeast Asia and mainland Australia, considerable work needs to be undertaken on sylvatic trichinellosis to determine the transmission routes and the animal species that play the most important role as reservoir of this infection for domestic swine and humans.

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