Society for the Promotion of Science (JSPS) twice continuously (2006-2008, 2009-2011). Akira Ito organized international symposia in Bangkok (2006) at JITMM2006 [4], Okinawa (2007) at the 21st Pacific Science Congress [5-9], Cheju at 17th ICTMM (2008), Bangkok (2009) at JITMM2009, Bangkok (2010) at JITMM2010. In 2011, we also expect to organize it in Bangkok at JITMM2011. These symposia are the major subjects sponsored by JSPS fund from 2006 until 2011.

From 2010, Akira Ito has been recommended to start a special project entitled "Development of molecular and immunological tools for detection of neglected cestode zoonoses" from the Ministry of Education, Japan (MEXT) for three years. This special fund is mainly for development of international collaborative research based on the establishment of the network by the JSPS fund.

Report

The first Workshop and seminar for the transfer of technology through joint projects

From 15 February 2011, we organized the first workshop of this new project and also simultaneously started seminars for the transfer of technology through collaboration for 3 weeks. In this report, we would like to introduce what we have been doing through this new project sponsored by the Japanese Government. A total of 23 participants including two PhD students from Cameroon and Iran studying at AMU, joined together from 15 Feb 2011 at AMU. Guests were from China (2), Mongolia (3), Thailand (2), Indonesia (3), Ethiopia (2), Finland (1) and Japan including AMU staff (8).

On 15 and 16 Feb 2011, we had the first workshop with an observer, Takashi Nishigaki, the project coordinator head from Japan Science and Technology Agency (JST), Ministry of Education (MEXT), Japan. After Akira Ito's brief welcoming remarks stressing that "We live together and share the science, technology and philosophy to do joint projects for control of cestode zoonoses", Tiaoying Li and Xingwang Chen from Chengdu, China introduced the present problems of taeniasis/cysticercosis in Sichuan, China with an excellent general overview of taeniasis/cysticercosis [10] and made very clear what they wanted to do on this topic in AMU: 1) seroepidemiology of cysticercosis where we had previously confirmed taeniasis/cysticercosis of *Taenia solium*, taeniasis of both *T. saginata* and *T. asiatica* in the past several years, 2) molecular identification of 51 tapeworms collected in October 2010 through the joint project with the Japanese team (Akira Ito, Munehiro Okamoto, Minoru Nakao, Tetsuya Yanagida, Agathe Nkouawa) and international consultants (Patrick Giraudoux, Francis Raoul from France and Philip S Craig from UK), 3) copro-PCR for 150 stool samples and 4) cysticerci collected from 16 pigs during the new year 2011 to detect hybrid metacestodes of *T. saginata* and *T. asiatica*, and 5) discuss the strategy for transmission ecology of cysticercosis from taeniaisis using GIS [6] which we have been doing as multilateral joint project in China (China, France, UK and Japan) using Japanese funds, with the aim of establishing the current transmission model of *T. solium* in Tibetan communities of Sichuan, China. Hybrid and hybrid-derived tapeworms were already confirmed not only from Thailand [11] but also from China (Yamane et al. in prep.; Nkouawa et al. in prep.).

The second speaker was Toni Wandra. He overviewed the present situation of taeniasis/cysticercosis in Indonesia. Taeniasis of *T. saginata* was rather common but cysticercosis of *T. solium* was very rare and sporadic in Bali, whereas taeniasis/cysticercosis of *T. solium* was still very common in Papua [12-16] and *T. asiatica* was not so rare in Sumatra [12]. Nyoman S Dharmawan presented serological studies of bovine cysticercosis experimentally infected with eggs of *T. saginata*. This is one of the joint projects with Munehiro Okamoto and Akira Ito. Kadek I Swastika presented an important topic from Karang Asem, northeastern part of Bali, where an Indonesian and Japanese joint team worked from 17 until 21 Jan 2011. His main purpose was 1) to investigate serology for people from Karang Asem, and 2) for people randomly taken in Wamena, Papua in July 2010, and 3) undertake molecular identification of *Taenia* samples from both Papua and Bali and also 4) confirm molecular and serological confirmation of one ocular cysticercosis in Bali.

Paron Dekumyoy and Teera Kusolsuk from Thailand focused on taeniasisis/cysticercosis in the border between Thailand and Myanmar [17,18] and reported 4 day field work in Tak province with Munehiro Okamoto and Akira Ito from 5 to 8 Feb 2011, just a few days before this seminar in Asahikawa. His colleagues and the Japanese participants performed microscopy of 150 stool samples and found taeniid eggs from 6 people. So, the main work was to identify the eggs by multiplex PCR and LAMP and do the same work using stool samples.

Abmed Davaajav and Anu Davaasuren from Mongolia summarized taeniasis cases in Mongolia [19]. The main purpose of this project was 1) molecular identification of *Taenia* spp. using multiplex PCR and compare it with copro LAMP, and 2) serodiagnosis for several CE cases. Temuulen Dorjsuren summarized echinococcosis in Mongolia [20,21]. Her main purpose was 1) molecular identification of G1 and G6 genotypes of *Echinococcus granulosus* sensu lato using approximately 50 CE cases and 2) confirm additional one AE case, and 3) serology for both CE and AE. These samples were provided from many collaborators in Ulaanbaatar through Akira Ito's continuous effort to establish a better network for all researchers involved in echinococcosis join together. It

was encouraging to hear that Mongolian researchers from different institutions joined together for the "Echinococcosis Working Group in Mongolia" [20,21].

Sissay M Mekonnen from Ethiopia summarized human taeniasis and taxonomy of *Taenia* from wild animals in Ethiopia. His main purpose was to analyze the taeniid worms collected from hyenas, since we were interested in obtaining molecular information on *T. hyaenae* [22]. Zerihun H Negasi presented echinococcosis in domestic and wild animals in Ethiopia. His main purpose was molecular identification of parasite specimens from camels, cattle and goats.

Antti J Lavikainen from Finland gave a brief talk on his interest in molecular phylogeny of Taeniidae including *Taenia* from wild bear in Finland and stressed his main purpose to pursue molecular work on this parasite and several others in Europe and Russia, and join with an Ethiopian project [23]. All Japanese researchers were basically the host scientists and gave brief introductions for their main studies and tools, which they would like to share with the guests. Minoru Nakao spoke on the molecular phylogeny of Taeniidae and molecular evolutional aspects of *Echinococcus* spp. worldwide and explained molecular approaches for parasite samples from all guests [24,25]. Yasuhito Sako gave new tools for serodiagnosis for echinococcosis and cysticercosis. He developed highly specific and sensitive serology for both AE and CE using recombinant antigens including the rapid immunochromatographic kits [26] and for cysticercosis using native and recombinant antigens [27]. This time, he established a novel simple method for purification of diagnostic antigens for cysticercosis (Sako et al., in prep.) and opened it for all guests. Tetsuya Yanagida discussed the haplotype network of *Echinococcus* spp. and *Taenia solium* [28]. Kazuhiro Nakaya summarized the usefulness of experimental animal models for these cestode zoonoses [29]. Munehiro Okamoto talked on the recent topics on the hybrids of between *T. saginata* and *T. asiatica* [11].

Finally, Takashi Nishigaki gave a perspective for the Governmental special fund for future collaboration and stressed that we should continue international collaboration projects and apply for future funding (Figure 1).

So, the levels in science, technology, knowledge and experience in parasitic diseases and evidence-based epidemiological studies were highly variable among the participants from different countries joined together in Asahikawa. However, this was not problematic but encouraged all participants to join together and help one another and improve the curiosity or interest for further studies and collaboration. PhD students from Cameroon and Iran also joined together. Agathe Nkouawa from Cameroon showed how to conduct multiplex PCR and LAMP for taeniasis and cysticercosis of all parasite samples from human or animal origins and copro-PCR and -LAMP for stool examinations, not only in the laboratory but also in the field for the real time identification of the species [30,31]. Tahereh Mohammadzadeh used mitochondrial DNA confirmation for *Echinococcus* spp. and serology for CE.

Outcome from the seminar from 15 Feb until 4 March 2011

Every Wednesday, we had a 2-3 h seminar to summarize what we had done.

1) China project: Of 51 tapeworms from 35 Tibetan carriers analyzed by multiplex PCR and LAMP, 9 worms from 4 carriers were confirmed as *T. solium*, 40 worms from 30 individuals were identified as *T. saginata*, and the remaining 2 worms from two carriers were confirmed as hybrids of *T. saginata* and *T. asiatica*. Additionally, one of the 35 carriers was identified as dual infection of *T. solium* and *T. saginata*. Serology for cysticercosis in the same Tibetan community revealed that 10.4% (25/240) showed positive response. Further imaging examination is necessary for these sero-positive individuals. Copro-PCR suggested that 35 (23.3%) of 150 stools were positive for *T. solium* or *T. saginata*. Of these 35 positive samples, 25 were verified as taeniasis by collection of tapeworms following treatment with pumpkin seeds combined with areca [32] and/or by microscopy, whereas the remaining 10 cases were newly diagnosed. In other words, copro-PCR could detect more taeniasis carriers in endemic areas.

2) Indonesia project: Although we could not find any *T. solium* carriers in Bali in the past decade, we finally succeeded in detection of several carriers from Karang Asem (Swastika in prep.). All including an immature cysticercus of an ocular cysticercosis case [33] were confirmed to be the Asian genotype of *T. solium* [34] by multiplex PCR and/or LAMP. Molecular identification of *T. solium* from Papua and Bali showed more similarity than we had obtained previously [35]. Further studies are necessary for such work to reach a conclusion on the origin of *T. solium* in Papua. Serology for cysticercosis in Bali and Papua showed critical differences. People in Bali showed relatively weak positive responses from few people, whereas those in Papua showed very strong positive responses from the majority of people [36]. As we know well, cysticercosis is highly endemic in Papua, but it is still sporadic and, therefore, we expect that the control of cysticercosis in Bali may be feasible after the establishment of the strategy for control of cysticercosis by both the central and local Governments. As the field survey has been carried out by the central CDC in Jakarta, Provincial CDC in Bali and Udayana University in Bali, we expect that we can control cysticercosis in Bali. By contrast, it is very difficult to control cysticercosis in Papua within a few decades [9,12,15,16].

Figure 1 This is a photo just after the two day workshop at Asahikawa Medical University on 16 February 2011 with consent of all participants.

3) Thai project: Stool examination by multiplex PCR and LAMP revealed that 6 taeniases were by *T. solium* (n = 5) and one was by *T. saginata*. As the carriers were not treated during our short stay in Feb 2011, we were setting up treatment of the people and additional stool examination in the same village and serology for cysticercosis. [We had a second visit to the same village for treatment of these carriers in May 2011. Unexpectedly, we failed in treatment of three of these carriers, who were basically refugees or immigrants from Myanmar and unable to move out. They moved to urban areas to obtain jobs without treatment. Therefore, these carriers are expected to become high risk persons who may cause secondary cysticercosis in the urban areas in the future.]

4) Mongolian project: All *Taenia* specimens were confirmed as *T. saginata* by multiplex PCR as was confirmed from another project coordinated by Abmed Davaajav in 2006 [17]. *Echinococcus* specimens from CE were confirmed to consist of G1 and G6 as we recognized it in advance in 2006 when Akira Ito invited one junior researcher under Abmed Davaajav [17] and the 6th AE case was confirmed after Bat-Ochir Oyun-Erdene at the Pathology Center, Ministry of Health showed the pathological data in 2010 to Akira Ito [18].

5) Ethiopian project: Molecular approaches for the *Taenia spp.* collected from hyenas showed at least three unknown different *Taenia* species. Morphological description is ongoing. We, including Ethiopians, Antti J Lavikainen and Japanese, have a great interest on the origin of human *Taenia* [22], since *T. solium* has a high homology with *Taenia* species found from African wild animals including hyena and others. In addition, parasite cysts from 11 sheep, 19 cattle and 16 camels were analyzed. *E. granulosus* G1 genotype was identified from all host species and *E. canadensis* G6 genotype from camels and cattle. Surprisingly, one cattle cyst represented an unknown *Taenia* species, the adult stage of which was found in hyenas.

Perspectives

Our research team at AMU has been working on the establishment of immunological and molecular diagnosis of cestode zoonoses, mainly echinococcosis, and taeniasis and cysticercosis. Confirmative studies are necessary for future and further studies for evidence-based control of such cestode zoonoses or any other infectious diseases.

During this period (from 2001 until 2007), four foreign researchers completed their PhD studies in our team: two students from China and one from Brazil were sponsored by the Japanese Government or other international funds (US-NIH RO1), and one sandwich PhD program student, Ronpaku, a researcher from Indonesia, was sponsored by the Japan Society for the Promotion of Science (JSPS). One guest from Cameroon received a Japanese Governmental scholarship to become a PhD

student at AMU from 2006 and was awarded a PhD in March 2011. Two guests completed their PhD thesis at Mahidol University and Akira Ito was an overseas examiner for them. In addition, Akira Ito was an overseas PhD examiner at the Jawaharlal Institute of Postgraduate Medical Education and Research, India in 2011 and will become an overseas examiner at Mahidol University for one of the guests who just started his PhD studies on taeniasis/cysticercosis.

Through such joint projects sponsored by MEXT, we continue to encourage colleagues who will actively work for control of such parasitic diseases as the key researchers and establish better networks. Our philosophy may be easily recognized by the authorship of the joint papers in Indonesia, Thailand, China, Mongolia and Cameroon. Basically, we do not become the first author for any of the primary studies from any countries but invite junior colleagues from the counterpart countries especially on the field work in their home countries, except in a few cases.

Acknowledgements

This first workshop was fully supported by the Asian Science and Technology Strategic Cooperation Promotion Programs sponsored by the Special Coordination Funds for Promoting Science and Technology, MEXT for 3 years from 2010 to Akira Ito. Also a similar strategy from 2006 until 2011 to establish the network for control of cestode zoonoses in Asia and Africa was supported by the Asia/Africa Scientific Platform Fund from the Japan Society for the Promotion of Science (JSPS) to Akira Ito. The studies described above have been supported by Grants-in-Aid for Scientific Research (21256003, 21406009 and 22590376) to Akira Ito, Munehiro Okamoto and Minoru Nakao, respectively, from JSPS.

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Authors' contributions

AI prepared the outline of the manuscript and delivered it to all participants to improve the contents especially on their own contributions. All participants amended the report and approved the final version of the manuscript with the photo.

Competing interests

The authors declare that they have no competing interests.

Received: 14 June 2011 Accepted: 21 June 2011
Published: 21 June 2011

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doi:10.1186/1756-3305-4-114
Cite this article as: Ito *et al.*: The first workshop towards the control of cestode zoonoses in Asia and Africa. *Parasites & Vectors* 2011 **4**:114.

Parasites & Vectors

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Parasites & Vectors 2012, **5**:18 doi:10.1186/1756-3305-5-18

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ISSN 1756-3305

Article type Review

Submission date 6 August 2011

Acceptance date 17 January 2012

Publication date 17 January 2012

Article URL http://www.parasitesandvectors.com/content/5/1/18

Taeniasis and cysticercosis due to *Taenia solium* in Japan

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Abstract

Taenia solium is a zoonotic cestode that causes taeniasis and cysticercosis in humans. The parasite is traditionally found in developing countries where undercooked pork is consumed under poor sanitary conditions and/or as part of traditional food cultures. However, the recent increase in international tourism and immigration is spreading the disease into non-endemic developed countries such as the United States. Although there has been concern that the number of cysticercosis cases is increasing in Japan, the current situation is not clear. This is largely because taeniasis and cysticercosis are not notifiable conditions in Japan and because there have been no comprehensive reviews of *T. solium* infections in Japan conducted in the last 15 years. Herein, we provide an overview of the status of *T. solium* infection in Japan over the past 35 years and point out the potential risks to Japanese society.

Keywords

Taenia solium,Cysticercosis, Taeniasis, Japan

Review

Taenia solium is a cestode species that causes taeniasis and cysticercosis in humans. Taeniasis refers to the intestinal infection with the adult stage of the tapeworm, which is acquired by eating undercooked pork contaminated with cysticerci (larval stage). On the other hand, cysticercosis refers to infection of various tissues with the larval stage of the tapeworm (cysticercus/cysticerci), which is acquired by ingestion of parasite eggs released from taeniasis carriers. Whilst taeniasis is asymptomatic in many carriers, neurocysticercosis (NCC), cysticercosis of the central nervous system, is still often lethal especially in remote areas in developing countries [1-3]. Although cysticercosis is one of the most important cestode zoonoses worldwide [4, 5], it is endemic mainly in remote or rural areas of developing countries where local people consume pork without the benefit of meat inspection. However, recent trends in international tourism into remote or rural areas, expansion of global business and an increase in immigrants and refugees have increased the number of taeniasis and cysticercosis cases in the developed country such as the United States [6, 7]. Globalization has

even resulted in taeniasis and cysticercosis cases being identified in communities where eating pork is prohibited by religious law [6, 8]. Some of these cases are believed to have occurred due to fecal-oral transmission of parasite eggs shed in the feces of housekeepers or food handlers who emigrated from endemic countries and harbored adult worms. Also, transmission is facilitated by poor or no knowledge of the risk of infection through consumption of local foods while visiting endemic countries. To prevent further outbreaks of cysticercosis in developed countries, the establishment of central or local governmental surveillance systems is an urgent task. In these systems, it is essential to introduce highly reliable detection tools and sustainable education programs. Molecular detection of taeniasis is highly reliable for differentiation of *T. solium* from other *Taenia* species in human stool specimens [1-4]. It is also available for histopathological specimens from cysticercosis patients [9-12]. Genotyping of mitochondrial DNA (mtDNA) enable us to assess where the infection was acquired from [9, 10]. In contrast, serology is important for confirmation of cysticercosis in patients with suspected NCC based on neuroimaging [2, 11].

At present, *T. solium* infection is not endemic in Japan and cysticercosis cases have been reported only sporadically. However, in the last 15 years, the number of foreign residents in Japan has risen from 1.4 to 2.2 million, and Japanese nationals staying abroad for a prolonged period of time (> 3 months) has also increased from 430,000 to 760,000 (Ministry of Foreign Affairs of Japan, 2010). Although greater movement of people has possibly increased the number of *T. solium* infections in Japan, the actual number of the cases is largely unknown as taeniasis and cysticercosis are not notifiable in Japan. In addition, a recent outbreak of human taeniasis due to *Taenia asiatica*, which also requires pig as the intermediate host, in Tokyo, Japan [13] prompts us to reevaluate the risk of *T. solium* infection in Japan. The aim of this study was, therefore, to grasp and summarize the current status of *T. solium* infection in Japan. In the present study, we review case reports published in Japan during the past 17 years, and report briefly on 3 previously unpublished cysticercosis cases, which can indicate the present situation and level or reliability in diagnosis of cysticercosis in Japan. The three new cysticercosis case reports were diagnosed using neuroimaging and

confirmed with immunoblot and enzyme-linked immunosorbent assay (ELISA) using recombinant chimeric antigens [14]. These individuals were also tested for taeniasis using multiplex polymerase chain reaction (PCR) [15] and loop-mediated isothermal amplification (LAMP) [16].

Literature review

The PubMed [17] and Ichushi–Web [18] databases were searched for papers and reports on cysticercosis in Japan from 1994 through 2010. In both databases, the words "*Taenia solium*", "cysticercosis" and "Japan" were used as the search terms. For comparison, summarized data on cysticercosis cases in Japan from 1976 to 1993 were evaluated from a previous review [19]. Table 1 summarizes the differences in the frequency of cysticercosis cases in the investigated periods. In 1994-2010, 39 cases (27 papers and 12 abstracts of conference presentations) were found (2.3 cases/year) and the incidence of reported cases was similar in 1976-1993 (2.4 cases/year). The male-to-female ratio in 1994-2010 was significantly lower than in 1976-1993 ($P < 0.05$, Fisher's

exact test). There was a recent tendency showing a wider generation including children and a larger number of women suffering from cysticercosis. In 1994-2010, 22 patients were Japanese (56.4 %), 11 patients were from Asian countries including China (n=6), Korea, Cambodia, Nepal, India and the Philippines, and 2 others were from Latin America (Brazil and Peru). The nationality was not provided for the remaining 4 cases. Among the Japanese patients whose travel histories could be ascertained, 13 patients visited Asian countries while only one visited Latin America. We have to stress that 7 patients had no history of travel abroad. In 1994-2010, there were 35 NCC, 7 subcutaneous (or muscular) (SCC), and 2 ocular cysticercosis (OCC) cases. Some patients had NCC plus SCC (n = 4) and NCC plus OCC (n = 1). Only one taeniasis case was reported as a concomitant infection with NCC. There was a crucial difference in the treatment of cysticercosis cases. When cysticercosis cases were diagnosed by serologic tests in advance, 78.6% (11/14) were treated only with chemotherapy, and 21.4% (3/14) were treated surgically. By contrast, only 12% of cysticercosis cases (3/25) either sero-negative and/or no serologic test

applied for were treated with chemotherapy, but 88% (22/25) of them were treated surgically, often being misdiagnosed as having a brain tumor [20-22].

Case reports

Case 1: In 2005, a 42-year-old Brazilian woman presented to an eye doctor with a visual impairment, and pappiledema. Upon neurological examination, she was diagnosed with communicating hydrocephalus. A ventriculo-peritoneal shunt was implanted and the hydrocephalus improved. Neuroendoscopic surgery showed multiple cysts in the subarachnoidal space, and histopathological examination indicated cestode-derived tissue. Serology for cysticercosis was strongly positive, but copro-multiplex PCR was negative for taeniasis. The patient was treated with praziquantel at first and then with albendazole. Post-treatment serology remained positive.

Case 2: A 38-year-old Japanese man expelled a single tapeworm in 2000. He was treated with pyrantel pamoate, a drug used primarily for nematode parasites. In 2004, he complained of headaches and multiple cystic lesions were found on brain

computed tomography (CT). However, at this time, no medical or surgical treatment was initiated because all of the cysts were deemed dead based on the CT image and the patient's normal eosinophil value. In 2009, he complained of a narrowing field of vision. Serology showed strong positive responses, but copro-LAMP was negative. The patient was treated with albendazole in 2010, and follow-up is ongoing.

Case 3: A 31-year-old Japanese man noticed a subcutaneous nodule on his neck in December 2009. When the number of nodules increased by May 2010, brain CT and magnetic resonance imaging (MRI) showed multiple cystic lesions in the brain and serology showed strong positive responses. Tapeworm proglottids were expelled in his stools at the beginning of July 2010 and were identified as *T. solium* by multiplex PCR. He remembered he had found a similar white noodle-like substance in 2009, but he did not care about it. Taeniasis was treated using Gastrografin (diatrizoate meglumine and diatrizoate sodium) at Mie University hospital in Mie, Japan on 14 July, but no worms were expelled. However, *T. solium* infection was confirmed by copro-LAMP and *Taenia* eggs

were identified microscopically. On July 28th 2010, the patient expelled additional worms. Then he was treated with Gastrografin and albendazole in August 2010, but tapeworm(s) were not expelled. However, it was considered that the patient became free from *T. solium* tapeworm after he found the worm by himself on 28th July, as copro-LAMP was negative until December 2010. In contrast, the subcutaneous and intracranial nodules disappeared within 4 weeks after the treatment.

The patient's travel history indicated that he had worked for one month in a rural area 150 km from Delhi, India on 3 separate occasions. The first, second and third visits were March-April 2008, October-November 2008 and March-April 2010, respectively. Based on this information, it was suspected that he acquired the parasite during his first or second stay in India. A mtDNA gene (chromosome *c* oxidase subunit 1) of the obtained proglottids was sequenced according to previous research [23], and was determined to be identical to the Indian haplotype of *T. solium* (GenBank Accession Number: AB066489). Due to the risk of the patient contaminating his living environment with parasite eggs

while infected with the intestinal form of *T. solium*, his wife and 4 year old son were tested serologically for cysticercosis. In addition, 41 colleagues who had also travelled to India since 2007 were tested serologically for cysticercosis, with 39 of these individuals also tested for taeniasis using copro-LAMP. To date, none of these individuals have tested positive for either cysticercosis or taeniasis. This case is notable as a rare imported case of *T. solium* taeniasis/cysticercosis in Japan.

Discussion

T. solium infection tends to be endemic in developing countries, because the main risk factors for infection are poor sanitation and free-roaming pig farming [24]. In Japan, the number of cysticercosis cases was highest during World War II (225 cases during 1936-1945) and then drastically decreased by 1994 (15 cases during 1986-1993) [19]. However, cysticercosis is now considered as an emerging public health problem in some developed countries mainly USA [6, 7, 25] and also in Canada [2, 26] and Europe where pig farming style has changed

from indoor to outdoor with immigrants from Latin America etc. [27-29]. Although it has become apparent that an increase in international travel raises the risk of importation of *T. solium* into Japan, the incidence of reported cases was almost the same in the current review (2.4 per year; 1994-2010) as in the previous review (2.3 per year; 1976-1993) [19]. However, the actual number of cases is most likely underestimated, as taeniasis and cysticercosis are not notifiable in Japan. To clarify the present situation of *T. solium* infection in Japan, advanced diagnostic tools should be effectively utilized under governmental recommendations. Also, *T. solium* infection should be included on Japan's list of notifiable infectious diseases.

Our laboratory in Asahikawa Medical University has been an exclusive reference laboratory for serodiagnosis in Japan from 1998 when we reported serologic data [14, 30-34]. We have been involved in many bi- and multi-lateral projects on taeniasis and cysticercosis mainly in Asia (China, Vietnam, Philippines, Thailand, Lao PD, Nepal, Indonesia, Papua New Guinea, India) and some in Africa (South Africa, Mozambique, Tanzania, Cameroon, Ethiopia)

[35-43]. Based on our own experience and from many other studies by other groups on the transmission studies of cysticercosis, it is possible that a single taeniasis patient or carrier can contaminate the living environment with parasite eggs and infect numerous others with cysticercosis. Thus, follow-up studies using immunological tests are necessary not only for the taeniasis patients but also for their family members, neighbours, and close relatives. Despite the fact that autochthonous cysticercosis has not been confirmed recently in Japan, 7 cysticercosis cases were identified without a history of travel abroad. Therefore, it is hypothesized that these cases acquired the infection from unknown carriers in Japan. MtDNA analysis using stool samples, eggs, proglottids or metacestodes is highly useful to assess where the infection was acquired [9-11, 15, 42].

In the United States, 3,937 NCC hospitalizations were identified in Los Angeles County from 1991 through 2008, and more than 90% of the patients were Latinos [44]. Other reports have also demonstrated that most of the NCC patients in the US were Hispanics that emigrated from endemic countries such as Mexico [6, 45, 46]. Although it has been considered that most of the NCC patients had

been infected in their homelands, a recent study conducted along the US-Mexico border revealed that the prevalence of taeniasis was 3% [47], indicating a certain number of *T. solium* taeniasis carriers are also crossing the border. A similar situation between Myanmar and Thailand has recently been reported [35]. In this study, approximately 3.3% (5/150) of refugees from Myanmar in a refugee village, Tak Province, Thailand, were confirmed to have *T. solium* taeniasis in February 2011. However, when the Thai group members re-visited the village in May 2011 to provide treatment to the taeniasis cases, 3 of the patients had gone to Bangkok before they could be treated (Kusolsuk et al. in prep.).

In contrast to the US, the majority of foreign residents in Japan are not Hispanic. There were approximately 2.2 million foreign residents in Japan in 2009, and 16% of them were Latin Americans, while 77% were Asians (The Ministry of Justice, Japan, 2010). From 1976 to 1993, cysticercosis was reported in 12 foreign residents in Japan, with 11 of the cases from East Asian countries including China and North and South Korea. However, the current review of the literature indicates an increasing risk of importing the disease from South and Southeast