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Taeniases and cysticercosis in Indonesia: past and present situations.

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Review article

The past and present situation of taeniases and cysticercosis in Indonesia

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SUMMARY

The main aim of this study is to overview the past and present situation of human taeniases and cysticercosis in Indonesia with future perspectives. Through joint project from 1996, we have confirmed *Taenia saginata* (beef tapeworm) in Bali, *Taenia solium* (pork tapeworm) mainly in Papua and sporadically in Bali, and *Taenia asiatica* in North Sumatra. These taeniasis cases were caused through eating uncooked pork and viscera of pigs for *T. solium* and *T. asiatica*, respectively, and beef for *T. saginata*. The distribution of these tapeworms in Indonesia is basically highly restricted by the traditional cultural and religious background in each island. *T. saginata* is rather common in Bali although people consume pork "*lawar*" much more than beef "*lawar*". Taeniases due to *T. saginata* or *T. asiatica* and *T. solium*, and cysticercosis due to *T. solium* have also been sporadically reported in some other islands. Among these species, *T. solium* is exceptional, since humans can be infected not only by larval stage (cysticerci) in pork but also by eggs released from tapeworm carriers, humans. Cysticercosis in humans, pigs and even dogs have been confirmed in Indonesia.

Key words: *Taenia solium*, *Taenia saginata*, *Taenia asiatica*, taeniases, cysticercosis due to *T. solium*, Bali, North Sumatra, Papua.

INTRODUCTION

Indonesia is an archipelago consisting of 17,504 islands. The five largest islands are Sumatra, Java, Kalimantan, Sulawesi, and Papua. Administratively the country is divided into 33 provinces (the new constitution of Indonesia in 2012 is divided into 34 provinces) with a total population of 237,641,326. The majority of the population of Indonesia is

Muslim (87.18%), whereas the remaining 12.82% consists of Christians, Buddhists, Hindus and others. Christian populations are the majority in certain districts in several provinces of Indonesia such as East Nusa Tenggara, North Sulawesi, Papua, and North Sumatra. By contrast, in Bali Provinces, the majority of the 3,890,757 inhabitants is Hindu (83.5%) (Statistics Indonesia, 2011). Different religious and socio-cultural background in these provinces may affect the number of cases or prevalence of the major human cestode parasites in Indonesia. Usually, taeniases by eating uncooked meat is rare in general in Indonesia, since Muslim people usually do not eat uncooked meat.

Historically, *Taenia saginata* taeniasis in Indonesia was reported in the 19th century, where Luchtmans found this disease among the Dutch people in East Java in 1867 (Oemijati, 1977). By contrast, taeniasis due to *T. solium* was identified from a Chinese living in East Kalimantan in 1940 (Bonne, 1940).

Through joint project from 1996, we have confirmed taeniases due to *T. saginata* in Bali, *T. solium* from Papua and Bali, and *T. asiatica* from Samosir Island in Lake Toba, North Sumatra. *T. saginata* taeniasis is rather common in Bali where local people consume uncooked beef dish (beef *lawar*) as a traditional local food (Simanjuntak *et al*. 1997; Wandra *et al*. 2007).

Taeniases due to *T. saginata* or *T. asiatica*, and *T. solium* and cysticercosis due to *T. solium* have also been sporadically reported from other provinces: Lampung, Jakarta, West Kalimantan, North Sulawesi, South Sulawesi, South-East Sulawesi, and East Nusa Tenggara (Fig. 1) (Simanjuntak *et al*. 1997; Margono *et al*. 2001*a*, 2002, 2004; Ito *et al*. 2004; Suroso *et al*. 2006; Wandra *et al*. 2007).

DISTRIBUTION OF TAENIASIS AND CYSTICERCOSIS

T. solium cysticercosis in Papua (former Irian Jaya)

In Papua, taeniasis/cysticercosis (T/C) cases due to *T. solium* were reported at first from Paniai district in early 1970s (Tumada *et al*. 1973*a, b*; Desowitz *et al*. 1977). In this district, increased number of cases of seizures and burns were reported from people in sleeping around the fire place at local house (Tumada *et al*. 1973*b*). During 1973-1976, the number of cases of burns increased up to 257, resulted from accidents due to epileptic seizures (Subianto *et al*. 1978). In Enarotali hospital, Paniai, a total of 15/170 hospitalized patients were positive for *Taenia* eggs (9%). Within 6 months (1972-1973), 13 cysticercosis cases were reported, and a total of 77.3% from suspected cysticercosis were serological positive (Desowitz *et al*. 1977).

Movement of people from endemic district (Paniai) to other districts, sometimes with pigs as traditional and socio-cultural life style appears to have spread the parasite to other 5 districts in Papua (Jayawijaya, Manokwari, Nabire, Pegunungan Bintang, and Puncak Jaya) (Table 1, Fig. 2) (Simanjuntak *et al*. 1997; Wandra *et al*. 2007; Salim *et al*. 2009) and even into Papua New Guinea (Fritzsche *et al*. 1990: Flew, 1998; Ito *et al*. 2004; Owen, 2006).

In Jayawijaya district, neurocysticecosis (NCC) appears to remain highly endemic, since people suffering from epileptic seizures and drowned in the river were reported from District Healt Office Services (Handali *et al*. 1997; Simanjuntak *et al*. 1997). During 1991-1995, the number of cases of epileptic seizures increased each year at a local health center with a total 293 new cases of epileptic seizures and 1,120 cases of burns. Serology using highly specific antigens, either native or recombinant antigens (Ito *et al*. 1998, 1999, 2004; Sako *et al*. 2000, 2013; Sato *et al*. 2003) and mitochondrial DNA (mtDNA) analysis (Yamasaki *et al*. 2004) revealed that the majority of cases of epileptic seizures and burns was caused by cysticerci of *T. solium* and approximately 25- 30% of healthy people are

asymptomatic cysticercosis as well (Wandra *et al*. 2000, 2003; Ito *et al*. 2004; Yamasaki *et al*. 2004).

An epidemiological study on T/C was carried out in 5 districts of Papua in 1996-2005. A total of 1,474 persons were surveyed using both questionnaires and physical examinations, detection of taeniasis by copro-ELISA and mtDNA analyses. Serology of people, pigs and dogs was conducted for the detection of antibodies against cysticerci of *T. solium*. A total prevalence of 13.0% for *T. solium* taeniasis was confirmed in Jayawijaya district. No *T. saginata* or *T. asiatica* has been found from Papua. A total seroprevalence of 15.7% cysticercosis was detected in all of five districts (Jayawijaya, Manokwari, Nabire, Paniai, and Merauke) (Fig. 2). The seroprevalence of cysticercosis in humans in each district was highly variable from 1.1% in Merauke (1997-1998) to 22.5% in Jayawijaya (1996-2002). There is no evidence that *T. solium* transmission occurs in Merauke. One woman showing a high antibody titer in 2007 was a transmigrant from South Sulawesi. Seroprevalence of cysticercosis in pigs in Jayawijaya ranged from 8.5-70.4% during 1998-1999 and in dogs ranged from 4.9-33.3% in 2000-2002 (Subahar *et al*. 2001; Ito *et al*. 2002, 2004; Margono *et al*. 2003; Wandra *et al*. 2007) (Table 1). As dog meat is available in Papua, dogs as well as pigs may have some function for the completion of its life cycle in Papua (Ito *et al*. 2002, 2004).

Salim *et al*. (2009) reported seroprevalence of cysticercosis and taeniasis in four districts: They are 20.8% and 7.0%, respectively in Jayawijaya, 29.2% and 9.6% in Paniai, 2.6% and 10.7% in Pegunungan Bintang, and 2.0% and 1.7% in Puncak Jaya. As we have no previous data on T/C in the latter two districts, it is impossible to evaluate these data, especially the uniqueness showing highest in prevalence of taeniasis but very low in that of

cysticercosis in Pegunungan Bintang without direct evidence other than indirect serological data.

The recent field survey of cysticercosis in Jayawijaya revealed that 15.5% (2011) and 8.3% (2012) in humans and 19% in pigs (2012) were seropositive for cysticercosis (Swastika *et al.* in prep.). The serological tools applied in Papua were by ELISA, immunoblot for both people and pigs, and the commercially available immunochromatographic rapid kit (ADAMU-CC, ICST Co. Ltd., Saitama, Japan) for people using recombinant antigens and native but highly purified antigens (Sako *et al.* 2013). Subcutaneous cysticerci of *T. solium* were confirmed from several sero-positive volunteers. Compared to serological data in Jayawijaya (1996-2009), seroprevalence of cysticercosis in humans and pigs appears to be relatively lower in 2011-2012 but further follow-up studies in bigger scales are necessary to discuss the future perspectives.

The data between two groups of sero-positive and -negative for cysticercosis in Jayawijaya (1996-2002) showed that the most important factors associated with cysticercosis were age (18 years or older), low level of education, and the habit of not washing hands before eating. Furthermore**,** among 506 families in Jayawijaya, surveyed during 1996-2005, it was reported that only 17% were defecated in a latrine (Wandra *et al.* 2007).

Taeniasis/cysticercosis in Papua New Guinea

There is a possibility of introduction of T/C due to *T. solium* to the neighboring country, Papua New Guinea (PNG) (Fritzsche *et al.* 1990; McManus, 1995; Flew, 1998; Ito *et al.* 2004; Owen, 2006; Dwyer, 2006). A serological survey of OK Teddy Mine in PNG (Fig. 2) was carried out in 1997 using approximately 600 human serum samples. Based on both

ELISA and immunoblot examinations, approximately 3% were confirmed cysticercosis serologically (Flew, 1998; Ito *et al*. 2004). It is, therefore, urgent to do field survey of T/C in PNG.

Taeniases/cysticercosis in Bali

Historically, the first report of cysticercotic pigs in Bali was published in 1928 (Le Coultre, 1928). Human subcutaneous cysticercosis (SCC) cases were reported in 1960 (Soebroto *et al*. 1960). There are several reports on *T. solium*, epileptic seizures, SCC, NCC, and seroprevalence of cysticercosis in Bali (Simanjuntak *et al*. 1977; Margono *et al*. 2001*b*, 2002; Ngoerah, 1975; Theis *et al*. 1994; Rodriguez-Canul *et al*. 1997; Sutisna *et al*. 1999; Sudewi *et al*. 2008; Wandra *et al*. 2006*a*, *b*, 2011).

Taeniasis cases have been observed in all nine districts (Gianyar, Badung, Denpasar, Bangli, Tabanan, Jembrana, Klungkung, Buleleng, and Karangasem) of Bali Province during 2002-2013 (Fig. 1). A total of 1,492 persons were surveyed using both questionnaire and physical examinations. *Taenia* eggs were detected by microscopic examination of faecal sample (Kato-Katz method). Identification of *Taenia* species using the expelled proglottids was carried out by mitochondrial DNA analysis (Yamasaki *et al*. 2004; Wandra *et al*. 2007; Myadagsuren *et al*. 2007). Serology of people (1,369) and pigs (228) was carried out for the detection of *T. solium* cysticercosis.

Among 1,492 people, a total of 123 *T. saginata* taeniasis cases were found and distributed in four districts (Gianyar, Badung, Denpasar, and urban area in Karangasem) (107, 1, 14, and 1 cases, respectively), and 9 cases of *T. solium* taeniasis in Karangasem (rural area). *T. solium* was first observed in rural area of Karangasem in 2011 (3 cases)

after one decade surveys in Bali from 2002 onwards (Fig. 1) (Wandra *et al*. 2011; Swastika *et al*. in prep.).

So far, there is no real evidence of *T. asiatica* in Bali (Table 2). We have a conclusion from interviews that it is due to the fact that the majority of local people love uncooked pork *lawar* but hate uncooked viscera of pigs. It is crucial difference from local people in Samosir Island in Lake Toba, North Sumatra (see below). However, several persons interviewed in Karangasem in 2013 told us that they consumed undercooked liver of pigs as well as pork. Therefore, the possibility of an epidemic of *T. asiatica* taeniasis remains at least in this area, especially when some taeniasis carriers of *T. asiatica* visit this area and pigs are contaminated with eggs of this parasite and meat and viscera of pigs without meat inspection are served as a local dish.

A total of seroprevalence of 2.4% *T. solium* cysticercosis was confirmed using both glycoproteins purified from *T. solium* cyst fluid (Ito *et al*. 1998) and chimeric recombinant antigen (Sako *et al*. 2000; Sato *et al.* 2003). Among 1,369 human serum samples examined after mass screening in the nine districts, serum samples from only 2 districts (Gianyar and Karangasem) showed seropositive to cysticercosis (2.3%, and 2.8%, respectively). A total of seroprevalence of 15.8% (36/228) [5 of 64 (7.8%) in 2011 (based on ELISA and immunoblot) and 18.9% (31/164) in 2013 (based on ELISA)] was detected in pigs in Karangasem (Table 2) (Swastika *et al*. in prep.). So, there is no doubt that Karangasem is exceptionally highly endemic of T/C in Bali.

During 2003-2010, a total of 13 and one cases of *T. solium* cysticercosis were reported sporadically from Sanglah Hospital, University of Udayana and Indera Hospital, Denpasar, respectively. These cases were mostly from people living in Gianyar and Karangasem and the remaining cases were recognized living in other districts. A total of 4 cases were

167 detected in the field during epidemiological survey in Gianyar (Table 3) (Sudewi *et al*.
168 2008; Wandra *et al*. 2011). It is assumed that the source of infection for *T. solium* in Bali
169 especially in Gianyar is due to *T. solium* carriers from Karangasem who periodically
170 migrated to other districts of Bali for looking for jobs during the dry season from April to
171 October.

172 There is a crucial difference in the socio-economic data of local people between Gianyar
173 (2002-2004) and other districts (2004-2010) including Karangasem (2011). Almost all
174 families in Gianyar have good sanitary facilities and do not defecate in the backyard, and
175 all pigs are kept indoors (Wandra *et al*. 2006*a*, *b*). People in Gianyar like to eat uncooked
176 beef "*lawar*", whereas most people in other districts eat cooked beef (Wandra *et al*. 2011).
177 *Lawar* is a traditional local dish of raw pork or raw beef. It suggests the reason why we can
178 detect taeniasis due to *T. saginata* every year in Gianyar. By contrast, in rural area in
179 Karangasem, 29% (18/62) of families have no sanitary facility and people defecate in the
180 garden, 83.9% (40/46), 10.9% (5/46) and 2.2% (1/46) of pig owners keep their pigs in a
181 fenced field, in open common pasture, and roaming free, respectively. Interviews of 62
182 respondents of 62 families in Karangasem in 2011 showed that all (100%) were Hindus,
183 83.9% (52/62) consumed pork *lawar* and 9.7% (6/62) consumed beef *lawar* (Swastika *et al*.
184 in prep.). Such crucial differences may be in part due to the crucial difference in geographic
185 situation between the two districts. Gianyar is located between Karangasem and the capital
186 city, Denpasar and basically flat area whereas rural area in Karangasem is the mountain
187 slope of Mt. Agung (3,142 m) (Fig. 1). Also, local beef contaminated with cysticerci of *T.*
188 *saginata* may be widely consumed in Bali, but only people who eat uncooked beef are
189 infected with *T. saginata* as shown in Gianyar. It cannot explain the reason why *T. saginata*
190 infections are not rare in people living in Badung, Denpasar, and urban area of Karangasem.

Uncooked beef *lawar* is prepared and sold in Gianyar exclusively. So, people in other districts may get infection due to consumption of beef *lawar* prepared in Gianyar through 1) during attending religious ceremonies in Gianyar, or 2) people from Gianyar bring out beef *lawar* as a gift mainly for the religious ceremonies for their relatives or friends living in other districts.

However, the source of infection for *T. saginata* taeniasis is still not clear, since cattle in Bali are also slaughtered in unlicensed slaughterhouses. Quality control of beef even in the markets is rather difficult by the limited number of meat inspectors (Wandra *et al*. 2006*a*, 2007). During 2002-2004, three of 56 *T. saginata* carriers in Gianyar were beef *lawar* sellers. Several other taeniasis carriers bought *lawar* from these sellers (Wandra *et al*. 2006*b*). In addition, screening of 15 *lawar* sellers in 2004 revealed that 40% (6/15) of them were *T. saginata* carriers (Wandra *et al*. 2011).

Taeniasis/cysticercosis in Samosir Island, Lake Toba, North Sumatra

Although *T. asiatica* was described as an independent species by Eom and Rim (1993), this parasite had well been recognized to be common in Asia for long time as "Asian *Taenia*" in people who ate meat and viscera of pigs but not of cattle in Taiwan, the Philippines, and Indonesia (Yokogawa, 1935; Huang *et al*. 1966; Kosin *et al*. 1972; Chao and Fan, 1986; Fan *et al*. 1987, 1990*a*, *b*; Kosman *et al*. 1988; Fan, 1988; Simanjuntak *et al*. 1997; Ito *et al*. 2003, 2005; de Leon, 2005). One example of this unique "Asian *Taenia*" was reported as common tapeworms from Samosir Island long years ago (Kosin *et al*. 1972). Epidemiological survey in 1986 and 1987 revealed that 21% (97/465) of 76 families in Samosir Island were infected with "Asian *Taenia*" (Kosman *et al*. 1988). These Indonesian parasitologists joined with Fan in Taiwan and confirmed the unique life cycle of this

215 "Asian *Taenia*" (Fan *et al*. 1990*a*, *b*). It is interesting to remind that eggs of "Asian *Taenia*"
216 develop into mature metacestodes in the liver of pigs and cattle but not in muscle.
217 Nonetheless, it has been stressed that *T. asiatica* from the liver of pigs. Difference from *T.*
218 *saginata* is the organotropism not in muscle but in the liver.
219 These Taiwan, Indonesian and Korean researchers expected "Asian *Taenia*" as an
220 independent species (Chao and Fan, 1986; Fan *et al*. 1987, 1990*a*). However, several others
221 working on molecular difference between "Asian *Taenia*" and *T. saginata* rather
222 recommended not describing it as an independent species (Zarlenga *et al*. 1991; Bowles
223 and McManus, 1994; Simanjuntak *et al*. 1997). The most recent molecular studies on *T.*
224 *asiatica* and *T. saginata* carried out in several areas where both species are sympatrically
225 distributed have revealed hybrids of these two species (Okamoto *et al*. 2010; Yamane *et al*.
226 2012, 2013). So, the species status is still under debate.
227 Recent epidemiological surveys of T/C and soil-transmitted helminthiases carried out in
228 2003, 2005 and 2006 revealed that six of 371 people (1.6%) from 285 families [2 of 58
229 (3.4%) in 2003 and 4 of 182 (2.2%) in 2005] were confirmed to be infected with *T. asiatica*
230 by multiplex PCR (Yamasaki *et al*. 2004; Wandra *et al*. 2007). We could not detect any
231 case of *T. asiatica* in 2006. There was no evidence of the occurrence of *T. solium* or *T.*
232 *saginata* in this island, since all tapeworms were identified to be *T. asiatica* by multiplex
233 PCR (Wandra *et al*. 2007). The residents of Samosir Island eat a traditional dish with
234 minced pork (Kosin *et al*. 1988; Fan *et al*. 1992). When they cut pork into small pieces,
235 they eat uncooked viscera (liver) which contains the cysticerci of *T. asiatica*, as a risk
236 factor for taeniasis. It is more common for the butcher to taste the small pieces of viscera of
237 pigs through preparation of these foods in North Sumatra (Wandra *et al*., 2006*b*, 2007).
238 Throughout our field surveys in Samosir Island in 2003, 2005 and 2006, microscopic

239 stool examination of a total of 371 samples revealed that 45 (12.1%), 44 (11.9%) and 28
240 (7.5%) were egg positive for *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms,
241 respectively. However, 30 (8.1%), 11 (3.0%) and 19 (5.1%) were mixed infections of both
242 *A. lumbricoides* and *T. trichiura*, both *A. lumbricoides* and hookworms and both *T.*
243 *trichiura* and hookworms. Furthermore, 15 (4.1%) were mixed infections of all three
244 nematode species (Wandra *et al*. in prep.). By contrast, we could not detect any *Taenia*
245 eggs. It indicates that taeniasis is far neglected NTD. We could confirm *T. asiatica* in
246 Samosir Island based on the questionnaire if they had any experience of expulsion of
247 proglottids. It was much more sensitive than microscopic detection of eggs in faeces. All of
248 the 285 respondents were Christians, 173 (60.7%) had no formal school education or
249 primary school, 242 (84.9%) were farmers or merchants, and 146 (51.2%) of families had
250 no sanitary facility. Available data from 96 respondents of 96 families on behavior and
251 personal hygiene showed that the most of families (82.3%) obtained water from spring,
252 6.3% consumed without boiling, 57.3% did not wash their hands before eating, 56.3% did
253 not wash their hands after defecating, and 39.6% ate raw vegetables and fruits. The drastic
254 decrease in the number of taeniasis due to *T. asiatica* in Samosir Island is considered to be
255 due to the change in eating boiled but not uncooked pork through sustainable education
256 (Wandra *et al*. 2007, 2011).
257
258 CONTROL STRATEGY
259 Considering the differences in cultures, religions, level of education, socio-economic levels,
260 etc., control strategy should be adopted to the local epidemiological situations. However
261 the followings are expected to take the priorities (Wandra *et al*. 2006*b*; Suroso *et al*. 2006):
262 1) Active case finding and treatment of tapeworm carries; 2) Periodic checks of the
263 traditional dish hygiene related to transmission of infection; 3) Periodic check of *lawar*

sellers' health (in Bali) including their family members; 4) Establishment of an inspection system to check the quality of beef/pork/visceral and look for distribution of infected animal; 5) Investigation of the family members and the neighborhoods of cysticercosis patients who were diagnosed at the hospital; 6) Sustainable public health education on the personal hygiene, environmental sanitation including improved practices related to pig and cattle raising to all communities, and 7) Encouragement of political commitment and inter-sectoral collaboration at local, national and international levels. Improvement of simple diagnostic laboratory tools, strengthening surveillance system and establishment of reference laboratories are also essential.

FUTURE PERSPECTIVES

Recent advances in immuno- and molecular-diagnostic tools, especially for the real-time detection of people and pigs and even dogs have revealed that cysticercosis due to *T. solium* is re-emerging disease in Bali and still emerging disease in Papua. In Bali, most of the people living in the cities and towns are keeping pigs indoor through sustainable education. However, through our international joint project over the last one decade, it has just been revealed from 2011 onwards that there are still some villages where people keep pigs outdoors and taeniasis and cysticercosis in local people and cysticercosis in pigs due to *T. solium* infection have been confirmed using the real-time detection tools (Ito, 2013). In 2011, we found three taeniasis carriers in the villages but in 2013 we found more number of carriers from people in the neighbor village and the beach side urban area of the same District. It is urgent task to prevent re-emergence of cysticercosis in Bali, Indonesia. So, we all are very serious to start the eradication of *T. solium* from this area in Bali. As Bail is a small island and basically rich with high education, we expect that we can eradicate this

disease from Bali. As cysticercosis was rather common in Bali two-three decades ago (Sutisna *et al*. 1999) but we could not detect any *T. solium* tapeworm carriers from 1996 until 2011 in Bali (Wandra *et al*. 2011), it is expected to be basically due to the sustainable education in Bali. However, we are now facing re-emergence of this disease in several villages in Karangasem. If this disease is distributed exclusively in this area, we have a great chance to eradicate it. Therefore, we have just started international joint project for transmission ecological studies of T/C in Karangasem with the third tool, GPS in order to obtain more concrete evidence (Giraudoux *et al*. 2013). In North Sumatra, people have changed their eating habitats from uncooked to cooked meat and viscera, even though they do not wash hands. Due to such drastic change in the life style, it is now very difficult to detect *T. asiatica* cases. It has taken approximately 30 years. If we can cut off the life cycle of *T. asiatica* or *T. solium* between pigs and humans, the pig is the ideal and economic animal which can scavenge human feces without any *Taenia* after eradication. However, STHs are still common in North Sumatra. So, sustainable education for washing hands before eating etc. and improvement for the better living environment is important. At moment, we have no crucial idea for control of taeniasis/cysticercosis in Papua. It takes much longer time for control of this disease in Papua than in Bali. However, it is better to know that the local Government in Papua and the central Government in Jakarta are keeping some budget for training public health personnel for control of this disease in Papua but not in Bali yet. Also, such strategies are affected by the improvement in economy. Another difficulty in general is that we have the weakness to temptation to eat uncooked foods. In this review, we have discussed taeniases and cysticercosis in the three islands where we have worked by ourselves. However, Indonesia is consisted more than 17,000 islands and people in each island may have their own traditional life style. Taeniasis

due to *T. saginata* or *T. asiatica* or *T. solium* in other islands has not been identified by molecular tools.

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Table 1.Summarized data of prevalence of taeniases and seroprevalence of cysticercosis due to *T. solium* in Papua by Distr
2003, 2007; Subahar *et al*. 2001; Ito *et al*. 2002; Salim *et al.* 2009).

Year	District	Prevalence of *T. solium* taeniasis (%)	Seroprevalence of cysticercosis in humans	pigs	dogs	Refe
1997-1998	Merauke	0/90	1/90 (1.1)*	NS	NS	Wa
2003-2004	Manokwari	NS	8/274 (2.9)	NS	NS	Wa
2004	Paniai	NS	1/61 (1.6)	NS	NS	Wa
2009	Paniai	(9.6)	(29.2)	NS	NS	Sal
2004-2005	Nabire	NS	10/105 (9.5)	NS	NS	Wa
2009	Peg. Bintang	(10.7)	(2.6)	NS	NS	Sal
2009	Puncak Jaya	(1.7)	(2.0)	NS	NS	Sal
1996-2002	Jayawijaya	19/146 (13.0)	203/902 (22.5)	NS	NS	Wa
1998-1999	Jayawijaya	NS	NS	(8.5-70.4)	NS	Su
2000-2002	Jayawijaya	NS	NS	NS	(4.9-33.3)	Ito
2009	Jayawijaya	(7.0)	(20.8)	NS	NS	Sal
2011	Jayawijaya	NS	28/181 (15.5)	NS	NS	Sw
2012	Jayawijaya	NS	9/109 (8.3)	38/200 (19.0)	NS	Sw

NS: no sample.

*: imported case.

Table 2.Summarized data of taeniasis cases and seroprevalence of cysticercosis by District in Bali, 2002-2013 (Wandra *et al*. Sudewi*et al*. 2008).

Year	District	No. of taeniasis cases			Seroprevalence (
		T. saginata	*T. solium*	*T.asiatica*	humans
2002-1013	Gianyar	107	0	0	10/431 (2.3)
2004	Badung	1	0	0	0/91 (0.0)
2004-1010	Denpasar	14	0	0	0/119 (0.0)
2007	Bngli	0	0	0	0/32 (0.0)
2008	Tabanan	0	0	0	0/42 (0.0)
2008	Jembrana	0	0	0	0/84 (0.0)
2009	Klungkung	0	0	0	0/100 (0.0)
2009	Buleleng	0	0	0	0/47 (0.0)
2006	Karangasem (urban area)	1	0	0	1/36 (2.8)
2011-2013	Karangasem (rural area)*	0	9	0	22/389 (5.7)

Table 3. Summarized data of cysticercosis in Bali, 2003-2010 (NCC: neurocysticercosis, OCC: ocular cysticercosis)

Hospital/Area (year)	Diagnosis	No. of cases	References
Sanglah Hospital/Denpasar (2003)	Disseminated Cysticercosis	1	Sudewi*et al*. (2008)
Sanglah Hospital/Denpasar (2004)	NCC	3 (1 with 2 nodules)	Sudewi*et al*. (2008)
Sanglah Hospital/Denpasar (2005)	NCC	1 (with 2 nodules)	Sudewi*et al*. (2008)
Gianyar District (2007)	NCC	1 (with *T. saginata* taeniasis: dual infection)	Wandra *et al*. (2011)
Sanglah Hospital/Denpasar (2009)	NCC	5	Sudewi*et al*. in prep.
Sanglah Hospital/Denpasar (2009)	NCC	3	Sudewi*et al*. in prep.
Indera Hospital/Denpasar (2010)	OCC	1	Swastika *et al*. (2012)
Gianyar District (2010)	NCC (1*) Cysticercosis (2**)	3 (with *T. saginata* taeniasis: dual infection)	Wandra *et al*. (2011) Swastika *et al*. (2012)

*Serology and CT Scan (+)

**Serology (+) but CT Scan (-)

Figure legends:

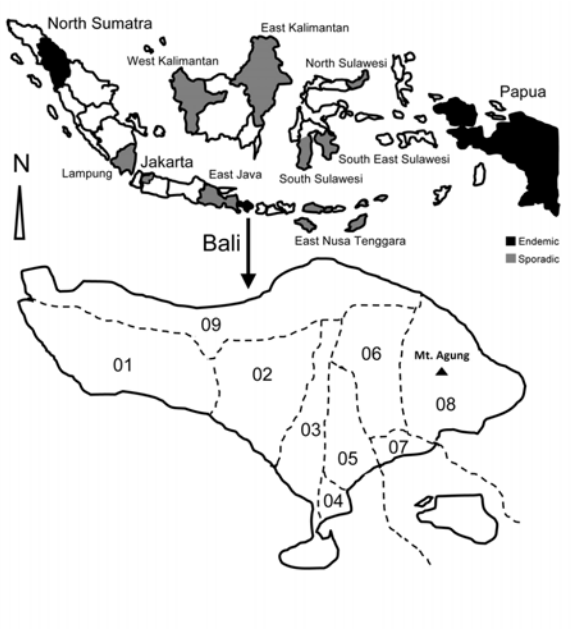
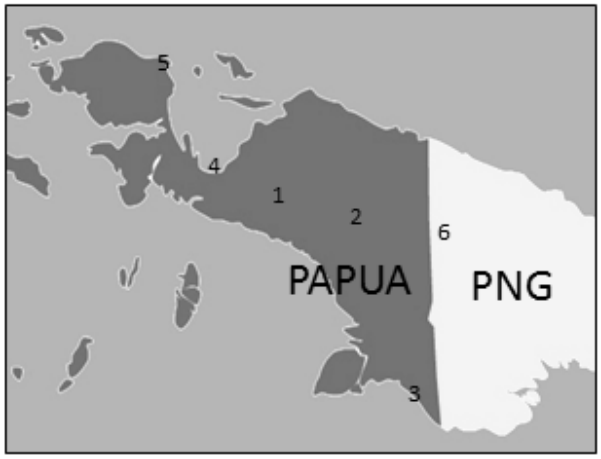


Fig. 1. Geographic maps of Indonesia (upper) and Bali (lower). 01-09: nine districts in Bali: Jembrana (01), Tabanan (02), Badung (03), Denpasar (04), Gianyar (05), Bangli (06), Klungkung (07), Karangasem (08), and Buleleng (09). Denpasar is the capital city of Bali.



569

570 Fig. 2. Map of Papua (former Irian Jaya) and Papua New Guinea (PNG). Numbers 1 – 6 are

571 District names in Papua and PNG. 1: Paniai where the first outbreak of NCC was reported

572 in 1970' (Tumada and Margono, 1973a, b; Desowitz *et al*. 1977), 2: Jayawijaya where it

573 was reported in 1990', 3: Merauke where only one imported case was found, 4 and 5:

574 Nabire and Manokwari, respectively, where it was reported in 2000', 5: , 6: OK Teddy

575 Mine where NCC cases were confirmed in 1997 (Flew, 1998; Ito *et al*. 2004; Owen, 2006).