

# Disease and Environment: Implications of Clonorchiasis Infection in Taiwan and Mainland China

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## 1. Introduction

Clonorchiasis is an infectious disease caused by *Clonorchis sinensis* (Chinese liver fluke, hereafter CS) and it is a food-borne zoonosis. To grow from eggs to adults, CS requires two intermediate hosts: the first one is fresh-water snail and the second one is fresh-water fish. The final hosts of CS are humans, pigs, dogs, cats, and mice; it can stay in human body for 15-20 years. Rivers, lakes and ponds provide suitable environment for this parasite to survive, but it is human actions that make this cycle of transmission to run over and over again.<sup>1</sup>

In modern medicine, CS was first found by McConnell on 9 September 1874 when he discovered flukes from the corpse of a Chinese woodworker in Calcutta, India. He reported that this fluke was a new species and that the infection was possibly related to the Chinese habit of eating half-cooked fish.<sup>2</sup> After reading McConnell's report, Cobbold, the most prominent parasitologist in England, agreed that this was a new species and suggested to name it *Distoma sinense*.<sup>3</sup> In 1877, MacGregor discovered three cases of infection among Chinese in Mauritius; and in the next year, McConnell found another case of Chinese coming from Hong Kong. In 1882, Baelz presented specimen of liver flukes discovered from corpses of Okayama residents at German Society for Natural Science and Folk Lore of East Asia and he contended that there were two species, one large and the other small; however, in 1885 Baelz restated that the two were identical. In addition to cases found among Chinese and Japanese, cases were also found during 1887-1905 in French Indo-China

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<sup>1</sup> For the life cycle of *Clonorchis sinensis* see, <http://www.dpa.cdc.gov/dpdx/HTML/Clonorchiasis/htm>, accessed on 2009/08/20.

<sup>2</sup> McConnell, 1875.

<sup>3</sup> Cobbold, 1875.

(today's Vietnam). In 1895, Blanchard gave a genus name, *Opisthorchis*, to this liver fluke and put *Distoma sinense* (Cobbold) under this category. In 1907, Looss separated *Distoma sinense* (Cobbold) from *Opisthorchis* and renamed it *Clonorchis*, but he contended that there were two species: the big one, *CS*, was more often found in China and the small one, *Clonorchis endemicus*, was more often found in Japan and Indo-China.<sup>4</sup> It was until 1917 when Kobayashi confirmed there was only one species with results of his experiment and morphological study.<sup>5</sup> Moreover, in 1924, Chen Pang proved that all specimens of *CS* collected from various places in China and Korea by the Union Medical School in Peking were all the same species.<sup>6</sup>

In Japan, It was proved in 1910 that the second intermediate host of *CS* was mostly fresh-water fish of Cyprinidae; and in 1917 it was proved that the first intermediate host was fresh-water snail, *Parafossaraulus striatulus var. japonicus*. (Yokogawa and Morishita, 1931:235) In Shanghai, it was proved in 1913 that cercariae of *CS* were parasites of small fish of Cyprinidae. (Houghton, 1913) In Taiwan, it was found in 1918 that straw fish (*Ctenopharyngodon idellus*) produced from ponds located at Shekou Village社口庄 (in today's Changhua County) was the second intermediate host of *CS*.<sup>7</sup> In 1924, snails and fishes collected around Shaoxing紹興, Zhejiang, were found to be infected and cats in the area were seriously infected with *CS*.<sup>8</sup> Thereafter, in 1925-1926, Faust and Khaw in China and Nagano Kanji in Japan respectively proved the process of incubation in the body of fresh-water snail.<sup>9</sup> Moreover, Faust and Khaw presented details of biology and morphology of *CS* in their monograph.<sup>10</sup> In 1936-1937, H. F. Hsü and his colleagues rectified the error of taking cercariae and metacercariae as *CS* itself and established the correct life cycle.<sup>11</sup>

Archaeological findings help in tracing the history of *CS* infection in China back to 2,300 years ago.<sup>12</sup> Excavations during 1956-1994 found that there were parasites in 14 corpses, of which 7 were identified as infected by *CS*. (See Map 1) Chronologically, these 7 corpses were: (1) A female dated the middle of Warring States Period (403-247 B.C.) excavated in 1994 at Guojiagang, Jingmen, Hubei 湖北荊門郭家崗; (2) A female dated the late Warring States Period excavated in 1982 at Mashan, Jiangling, Hubei湖北江陵馬山; (3) A male named Sui Shao-yian dated the Western Han Dynasty around 168 B.C. excavated in 1975 at Fenghuangshan,

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<sup>4</sup> Faust and Khaw, 1927: 3-5.

<sup>5</sup> Kobayashi, 1917.

<sup>6</sup> Faust, 1925b.

<sup>7</sup> Ōi, 1919.

<sup>8</sup> Faust and Balow, 1924.

<sup>9</sup> Yokogawa and Morishita, 1931: 238.

<sup>10</sup> Faust and Khaw, 1927: 9-116.

<sup>11</sup> Hsü and Khaw, 1936; Hsü and Chow, 1937.

<sup>12</sup> Wu De, 2002.

Jiangling, Hubei湖北江陵鳳凰山; (4) A male dated the Northern Song Dynasty (960-1126) excavated in 1973 at Hejiazhao, Hengyang, Hunan湖南衡陽何家皂; (5) A female, nee Zhou (1423-1502), the wife of Dai Jin, Minister of the Board of Work in the Ming Dynasty (1368-1644), excavated in 1956-1957 at Meihuacun, Dongshan, Guangzhou廣州市東山梅花村; (6) A male dated 1558 excavated in 1980 in Fuqing, Fujian福建福清; and (7) Chen Miao-zhen, the wife of a Minister of the Board of Household in the Ming Dynasty, excavated in 1980 in Fuzhou, Fujian福建福州. It is notable that except for the Northern Song case which was a single infection of CS, other cases were infected by multiple parasites.<sup>13</sup> It should also be noted that microscopic examination of eggs found in the corpse excavated at Mashan confirmed that there was no difference in the morphology of ancient and modern CS; and analysis of ribosomal internal transcribed spacer regions (ITS) using eggs found in the corpse excavated at Fenghuangshan confirmed that there were 15 differences of nucleotide positions for ITS1 sequence but no difference for ITS2.<sup>14</sup>



Map 1: Archaeological Discoveries of Clonorchiasis Infections in China

<sup>13</sup> Hsiao Fan, 2002: 9-11.

<sup>14</sup> Liu Wen-qi et al, 2007.

A practice of utilizing feces in fish culture that helps inducing the propagation of *CS* could be traced back in Chinese history at least to the mid Northern Song Dynasty, and a practice of building latrines or pigpens along fish ponds was found in many places in South China in the Ming Dynasty.<sup>15</sup> These practices were still quite popular even in the late 1990s as can be seen from many surveys discussed in this paper. It should also be noted that in the 1970s, a practice of farm management by building pigpens along fish ponds was once promoted in Taiwan.<sup>16</sup> Through these practices of fish culture, people tried to recycle the waste by letting excrements flowing into water to feed fishes; however, the danger of transmitting parasitic diseases was ignored.

Moreover, the custom of eating raw or half-cooked fish had a long tradition in China. This cuisine provides a chance for metacercariae of *CS* to enter human body and induces diseases related to liver and gallbladder. The custom of feeding cats and pigs with fishes also helps in producing animal hosts around the living environment of the people.

Since the late nineteenth century, major infected areas of *CS* were in East Asia, including Japan, Korea, Mainland China, Taiwan, and Vietnam.<sup>17</sup> At some places in Miyagi Prefecture, Japan, the infection rate reached more than 50% in 1883.<sup>18</sup> According to a report of the World Health Organization, the infection rate of Japan in 1950 was 2.9%, but in 1991 there was no infection found among 1 million stool samples. In Korea, the infection rate during the 1950s reached 40% and remained above 2% during 1982-1992.<sup>19</sup> In the early twenty-first century, it was estimated that there were 35 million people infected around the world, of which 15 million were in China.<sup>20</sup>

This paper is attempted to give a comprehensive review on the infection of *CS* in Taiwan and Mainland China with major rates charted in maps. The investigators mostly obtained the infection rate by fecal (stool) examinations and the positive rate by intradermal (skin) tests or serum tests with various methods.

## **2. The Infection of *Clonorchis sinensis* in Taiwan**

In Taiwan, studies on the topic before 1950 were mostly published in the *Journal of Formosan Medical Association* and afterwards, in various journals. Map 2 shows

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<sup>15</sup> Hsiao Fan, 2002: 24-28.

<sup>16</sup> Chen Eng-rin and Yen Chuan-min, 1981.

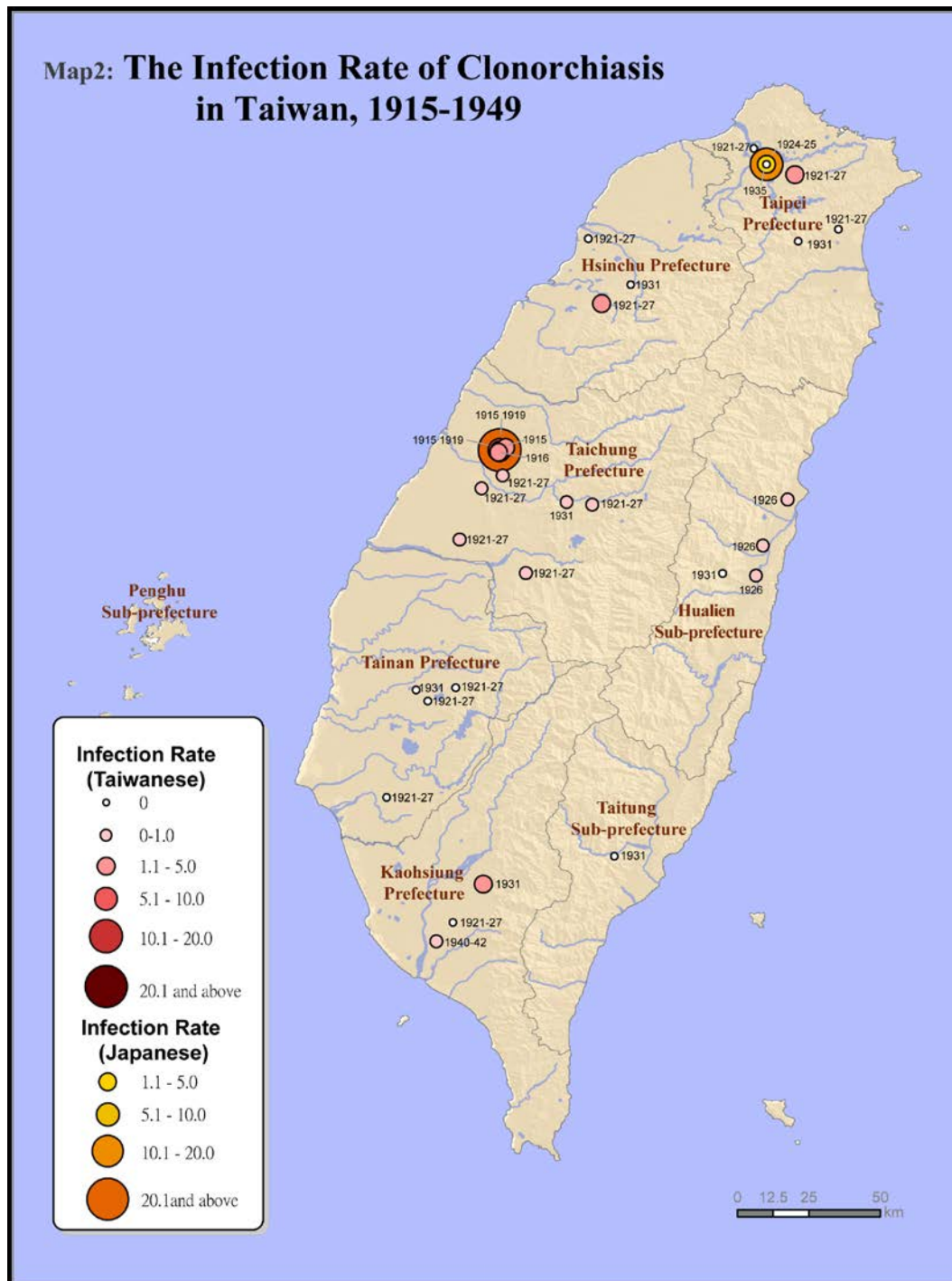
<sup>17</sup> Faust, 1925a; Faust and Khaw, 1927.

<sup>18</sup> Komiya and Suzuki, 1964.

<sup>19</sup> WHO, 1995: 98-99.

<sup>20</sup> Lun Zhao-rong et al., 2005: 31.

the infection rates in Taiwan in the first half of the twentieth century.



Map 2: The Infection Rate of Clonorchiasis in Taiwan, 1915-1949

In general, Japanese living in Taiwan had a higher infection rate than Taiwanese. In regards to patients at Taichung Hospital, in 1915, the infection rate of Japanese was 40% (32/80) and Taiwanese 7% (3/41); and in 1919, 24% (12/50) and 5% (2/40) respectively. At Taipei Hospital, in 1924-1925, the infection rate of Japanese was

10.6% (59/555) while there was no record regarding Taiwanese patients.<sup>21</sup>

In respect to students, at Taichung Middle School, the infection rate of Taiwanese was 5% (3/60) in 1915 and 3.3% (1/30) in 1916. At Private Commercial and Industrial School in Taipei, the infection rate of Japanese was 11.0% (4/35) and Taiwanese was 0.8% (1/126) in 1925. At Taipei Medical School, the infection rate of Japanese was 2.5% (3/121) while Taiwanese had no infection (0/139) in 1935.<sup>22</sup>

As for general residents, in 1915 the Japanese living in Middle Taiwan had an infection rate of 33.8% (44/130) while Taiwanese had no infection (0/219). During 1915-1916, three surveys among Taiwanese in Middle Taiwan found the infection rates of 3.6% (8/221), 4.3% (3/70) and 5.0% (6/120) with an average of 4.1% (17/411). In 1926, the infection rate of residents at three Japanese villages in Hualiangang District 花蓮港廳 was 0.6% (4/716), which was much lower than the rate of Japanese living in Middle Taiwan.<sup>23</sup>

During 1921-1927, investigations in rural area showed that infection rates varied at different types of villages. At the mountain villages, the infection rate was 3.6% (49/1354) in Taipei District and 0.3% (14/5627) in Taichung District; at the hillside villages, it was 2.1% (25/1195) in Hsinchu District and 0.2% (7/3896) in Taichung District; at the plain villages, only Taichung District had 0.6% (17/2808). As for Tainan and Kaohsiung Districts, no infection was found in all types of villages.<sup>24</sup> According to the 1931 health survey data, the infection rate of Taiwanese was 0.04% (26/74103) and there was no significant difference between male and female. Among the districts, Kaohsiung had 2.36% (21/8905) and Taichung had 0.05% (5/11129), while other districts had no infection. (HD, 1931: 42-49) During 1940-1942, the infection rate of residents at Wandan Village 萬丹庄 in Kaohsiung District (in today's Pingtung County) was 0.07% (11/16619).<sup>25</sup>

In short, during the Japanese colonial period in Taiwan, the infection rate of CS among Taiwanese was lower than Japanese, but the infection of Taiwanese was increasing and appeared at more places. In the late 1910s, both Ōi and Furuichi contended that Taiwanese had been influenced by Japanese in acquiring the habit of eating raw fish and thus more people were infected. Ōi also conducted surveys in Middle Taiwan and found that, in general, Taiwanese tended to eat cooked food, but residents at Yuanlin 員林 and Beidou 北斗 (in today's Changhua County) had an old habit of eating raw fish. A patient confessed that he liked to eat “yusheng” (魚生, raw fish gruel) and it was found the straw fish produced from his pond was infected.<sup>26</sup>

<sup>21</sup> Ōi 1915, 1916; Furuichi, 1919; Yamazaki, 1925.

<sup>22</sup> Ōi 1915, 1916; Yamazaki, 1925; Morioka, 1935.

<sup>23</sup> Ōi 1916, 1919, 1927.

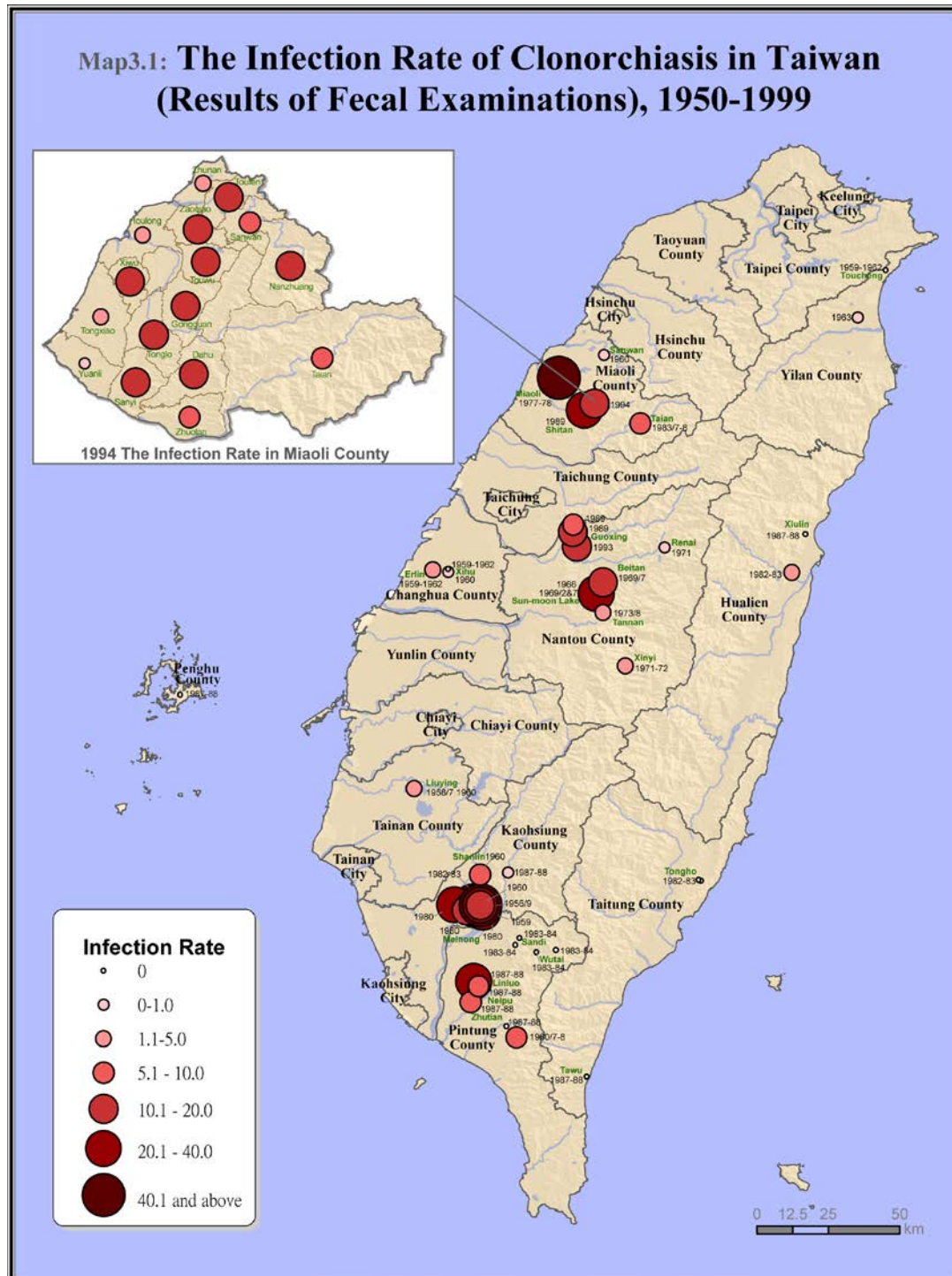
<sup>24</sup> Suzuki, 1929.

<sup>25</sup> Huang Teng-yun, 1947:123.

<sup>26</sup> Ōi 1915:825; 1919: 112-114; Furuichi, 1919: 121.

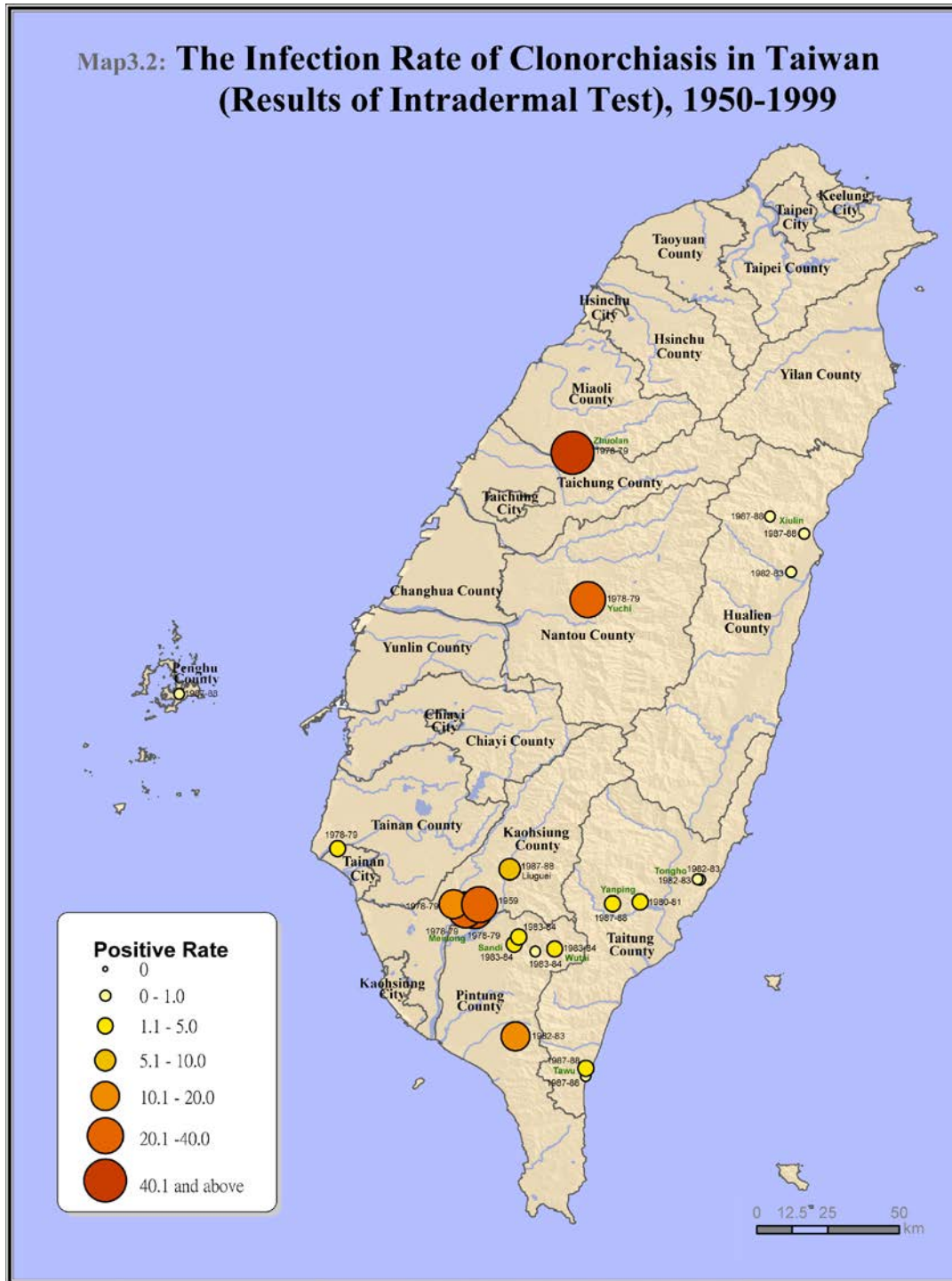
In this regard, this patient might be an immigrant originated from Guangdong and this local affiliation will become clear in discussion below.

In the later half of the twentieth century, the infection area of CS in Taiwan concentrated mostly in Kaohsiung and Pingtung Counties in the South and Miaoli and Nantou Counties in the Middle. Maps 3.1 and 3.2 show the infection rates after 1950.



Map 3.1: The Infection Rate of Clonorchiasis in Taiwan

(Results of Faecal Examinations), 1950-1999



Map 3.2: The Infection Rate of Clonorchiasis in Taiwan  
(Results of Intradermal Tests), 1950-1999

Meinung Township美濃鎮, Kaohsiung, was a highly endemic area of CS. The residents of Meinung are mostly Hakka and they liked to eat raw fish. From 1956 to



1983, there were many surveys at this town. The infection rate among residents was 22.4% (115/514) in 1956, 51.9% (69/133) in 1959, and 34.1% (115/337) and 10.2% (76/744) in 1960.<sup>27</sup> In 1978-1979, intradermal tests among students and teachers found that the positive rates of students in four groups were respectively 37.7% (93/247), 34.8% (1633/4688), 27.6% (300/1089), and 17.5% (213/1217); and those of teachers 53.9% (7/13), 51.9% (83/160), 42.6% (23/54) and 42.3% (47/111) respectively.<sup>28</sup> In 1980, fecal examinations among students and teachers found the infection rates of students at two middle schools were 20.2% (105/521) and 12.3% (114/442) respectively; at two occupational schools, 16.1% (24/149) and 14.2% (16/113) respectively; and teachers, 37.5% (6/16), 50% (5/10), 38.1% (16/42) and 7.1% (1/14) respectively.<sup>29</sup> In 1982-1983, surveys at Meinung Elementary School found the infection rates of pupils and teachers were 52.3% (45/86) and 73.7% (14/19) respectively.<sup>30</sup> In short, the infection rate of CS at Meinung was rather high with the highest rate reached more than 70% in the 1980s.

In addition, in 1987-1988, intradermal tests at Liuguei Rural Township六龜鄉, Kaohsiung, found the positive rate among elementary school pupils was 0.8% (6/800) and among residents 6.1% (18/297). Additional fecal examinations of pupils showed the infection rate was 0.3% (2/714).<sup>31</sup>

In Pingtung County, surveys in 1982-1983 at 12 elementary schools had the pupils first to answer whether they had experiences of eating raw fish and then those with positive answers received further examinations. The intradermal tests showed the positive rate was 0.8% (6/800) and the fecal examinations found the infection rate was 0.3% (2/714).<sup>32</sup> In 1983-1984, investigations among pupils and residents at 2 rural townships, Wutai霧臺 and Sandi三地, found a very small positive rate and no infection rate.<sup>33</sup> In 1987-1988, the infection rates of villagers at Zhuwei竹圍, Toulun頭崙, and Xintian新田 were 8.7% (59/677), 10.0% (84/843), and 20.1% (162/806) respectively. These three villages were new endemic areas of CS, the villagers were Hakka and their habit of eating raw fish was similar to other well known endemic areas.<sup>34</sup>

In Miaoli County, the earliest survey was done in 1960 with 269 residents of Sanwan Rural Township三灣鄉 and found the infection was 1%.<sup>35</sup> At Miaoli Township苗栗鎮, investigations in 1977-1978 among students of elementary, middle,

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<sup>27</sup> Hsieh Hsien-chen, 1959; Chow Lien-pin, 1960; Kuntz et al., 1961; Huang Wen-hsien et al., 1965.

<sup>28</sup> Wang Jiunn-shiow et al., 1980.

<sup>29</sup> Wang, Jiunn-shiow et al., 1981.

<sup>30</sup> Chen and Yen, 1985a.

<sup>31</sup> Yen Chuan-min et al., 1988.

<sup>32</sup> Chen and Yen, 1985a.

<sup>33</sup> Chen and Yen, 1985b.

<sup>34</sup> Yen Chuan-min et al., 1988.

<sup>35</sup> Kuntz et al., 1961.

and high schools as well as teachers and civil servants found the infection rates were 3.1% (41/1304), 7.1% (8/112), 7.9% (8/101) and 55.7% (379/681) respectively. There was no significant difference among male and female students, but among teachers and civil servants, the difference was significant as the male had 60.0% (254/423) and female 48.4% (125/258). Moreover, the town residents were classified into four groups with the results of different infection rates: Hakka 63.0% (119/189), Cantonese 51.3% (20/59), Fukienese 20.0% (5/25), and others 37.0 (30/81); and for those who came to work in the town from outside, the infection rate was 23.9% (49/205).<sup>36</sup> At Chuolan Rural Township 卓蘭鄉, residents who received intradermal tests in 1978-1979 had the positive rate of 53.3% (8/15).<sup>37</sup> At Taian Rural Township 泰安鄉, Atayal aborigines received fecal examinations in 1983 and the infection rate of adults was 26.4% (19/72), middle school students 2.5% (3/121), elementary school pupils 2.0% (1/49), and the total was 9.5% (23/242).<sup>38</sup> At Zhumu Village 竹木村, Shitan Rural Township 獅潭鄉, the AMS III method (a centrifugal sedimentation technique) was applied in 1989 to do fecal examinations for villagers and found the infection rate was 21.3% (43/202).<sup>39</sup>

In 1994, a comprehensive survey in Miaoli County for residents of 53 villages at 16 townships found the average infection rate was 11.6% (936/8028). There were 8 townships with the rate above the average: Tongluo 銅鑼 20.0% (112/561), Touwu 頭屋 20.0% (104/521), Sanyi 三義 19.1% (115/602), Dahu 大湖 18.1% (86/476), Xihu 西湖 17.3% (77/444), Gongguan 公館 16.8% (88/525), Toufen 頭份 12.6% (60/476), and Nanzhuang 南庄 12.0% (54/450); and another 8 townships had the rate below the average: Zaoqiao 造橋 10.1% (78/775), Zhuolan 8.6% (42/489), Taian 8.6% (26/304), Sanwan 6.8% (34/499), Houlong 後龍 4.9% (24/488), Zhunan 竹南 3.4% (20/585), Tongxiao 通霄 2.6% (10/393), and Yuanli 苑裡 0.5% (2/440). Moreover, residents of 13 townships were further grouped into Hakka, Fukienese, and Aborigines and the infection rates were found respectively 14.9% (864/5819), 2.2% (42/1905) and 8.6% (26/304). Apparently, Hakka had the highest infection rate and there was a significant difference between male 20.6% (2574/2785) and female 9.6% (290/3034).<sup>40</sup> It is also notable that the infection rate of aborigines was higher than that of Fukienese; the Atayal people had a custom of eating raw meat and hence it was apt for them to acquire habit of eating raw fish.<sup>41</sup>

In Nantou County, the first investigation conducted in 1966 among residents of

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<sup>36</sup> Ong and Lü, 1979.

<sup>37</sup> Wang Jiunn-shiow et al., 1980.

<sup>38</sup> Lu Jin-lang et al., 1987.

<sup>39</sup> Cheng Mei-ying et al., 1990.

<sup>40</sup> Chou Chun-hsiung et al., 1994.

<sup>41</sup> Taiwan aborigines were infected by tapeworm because of eating raw meat see, Yokogawa and Kobayashi, 1928. During 1971-1992, the total infection rate of tapeworm among aborigines was 11% (3104/27359) see, Fan Ping-chin et al., 2001a.

Huafanshe 花番社 around the Sun-moon Lake found the infection rate was 39.0% (24/62). In February and July 1969, two surveys found the infection rates were 51.9% (81/156) and 43.9% (111/253) respectively; and for those who received examinations in both times, the infection rate was 58.9% (43/73). Moreover, in July 1969, a survey at Beitan 北潭, a nearby village, found the infection rate was 10.7% (6/56).<sup>42</sup>

In 1971, the aborigines at Jenai Rural Township 仁愛鄉 received examinations and the infection rate was 0.5% (2/438).<sup>43</sup> In 1971-1972, surveys among aborigines at Fazhi 法治 and Qinai 親愛 villages in Xinyi Rural Township 信義鄉 found one case at each village and the total infection rate was 1.3% (2/150).<sup>44</sup> In 1978-1979, intradermal tests conducted at Shuishhe Village 水社村 in Yuchi Rrual Township 魚池鄉 found the positive rate of residents was 22.0% (9/41), elementary and middle school students 14.3% (36/251), and teachers 7.9% (3/38).<sup>45</sup> In 1989, the AMS III method was applied to examine the residents of Changliu 長流 and Changfeng 長豐 villages in Guoxing Rural Township 國姓鄉 and found the infection rates were 10.6% (29/275) and 9.3% (30/323) respectively.<sup>46</sup> In 1993, residents of 13 villages in Guoxing received examinations again and found the infection rate was 16.9% (297/1758).<sup>47</sup>

In addition to the above four counties, occasional surveys were done in other counties and the infection rates were rather low. At Liuying Rural Township 柳營鄉, Tainan, the infection rate was 2.1% (6/280) in 1958 and 4.0% (13/329) in 1960.<sup>48</sup> In 1978-1979, at Annan District 安南區 in Tainan where the practice of combining fish culture and animal husbandry was adopted, students and teachers of an elementary school received intradermal tests and the positive rates were 2.3% (5/221) and 0% (0/9) respectively.<sup>49</sup> In Changhua County, infection rates at three places around 1960 were as follows: Beishiwei 北勢尾 1.0% (2/246), Liutzugou 柳子溝 2.0% (1/50), and Beishili 北勢里 no infection (0/114).<sup>50</sup>

In Eastern Taiwan, a survey of 115 residents at Toucheng 頭城, Yilan, around 1960 found no infection. (Kuntz and Wells, 1967) In 1963, a survey among pupils of Yilan Elementary School found the infection rate was 0.2% (1/637).<sup>51</sup> In Hualien, there were two surveys. The first survey was conducted in 1982-1983 with the elementary school pupils and teachers at Ji-an Rural Township 吉安鄉. The

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<sup>42</sup> Kuntz, 1966; Clarke et al., 1971.

<sup>43</sup> Cross et al., 1971.

<sup>44</sup> CMC, 1972.

<sup>45</sup> Wang Jiunn-shiow et al., 1980.

<sup>46</sup> Cheng Mei-ying et al., 1990.

<sup>47</sup> Yeh Chin-lung et al., 1993.

<sup>48</sup> Hsieh Hsien-chen, 1959; Kuntz et al., 1961.

<sup>49</sup> Wang Jiunn-shiow et al., 1980.

<sup>50</sup> Kuntz et al., 1961; Kuntz and Wells, 1967.

<sup>51</sup> Kim and Kuntz, 1964.

intradermal tests were done and found the positive rates were 0.8% (4/500) and 0% (0/9) respectively. Students with positive rates also received fecal examinations and the infection rate was 2.9% (1/34). The second survey was conducted in 1987-1988 at Xiulin Rural Township 秀林鄉 and found the positive rates of the pupils and residents were both 0.9% (4/462 and 4/452 respectively), but fecal examinations for students found no infection.<sup>52</sup>

In Taitung, intradermal tests in 1980-1981 at Yenping Rural Township 延平鄉 found the positive rate of pupils at five elementary schools was 1.8% (5/286) and that of residents 3.6% (14/394). In 1982-1983, at Tonghe Rural Township 東河鄉, the positive rate of pupils was 0.9% (7/738) and that of residents 0.7% (2/274). In 1987-1988, at Dawu Rural Township 大武鄉, the positive rate of pupils was 1.0% (5/482) and that of residents 1.3% (4/319). But fecal examinations of these three surveys did not find any infection.<sup>53</sup>

In Penghu, at the off shore islands, intradermal tests of pupils in 1987-1988 found the positive rate was 0.4% (7/1652), but fecal examinations found no infection (0/780).<sup>54</sup>

It should be noted that since the 1990s, the infection of CS in Taiwan was under control with the curing of Praziquantel; but after the opening of trade and traveling between Taiwan and Mainland China as well as the entrance of foreign workers and brides, individual cases were still reported by the media recently. For instance, in 2002, it was reported that a Taiwanese merchant was infected because of eating raw fish in the Mainland. (TTNN, 2002) In 2005, Kaohsiung Medical School reported the story of a bride from the Mainland with infection of CS.<sup>55</sup>

Special concerns were also given to *Opisthorchis viverrini* (Thai liver fluke). For instance, the health examinations of foreign laborers entering Taiwan from January 1991 to February 1993 showed that the infection rate of *Opisthorchis viverrini* among the Thai laborers was 2.3% (238/10194).<sup>56</sup> The 1993 records of health examinations for the Thai laborers at Neihu General Hospital in Taipei showed that the infection rate of *Opisthorchis viverrini* was 9.1% (21/232); and an investigation in Middle Taiwan showed the infection rate was 12.7%.<sup>57</sup> In 1993-1996, a research project supported by the Health Administration found the infection rate of *Opisthorchis viverrini* among the Thai laborers was 4.9% (2611/53231). And animal experiments also suggested that it was possible to transmit *Opisthorchis viverrini*

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<sup>52</sup> Chen and Yen, 1985a; Yen Chuan-min et al., 1988.

<sup>53</sup> Chen Eng-rin et al., 1984; Chen and Yen, 1985a; Yen Chuan-min et al., 1988.

<sup>54</sup> Yen Chuan-min et al., 1988.

<sup>55</sup> Yang Cheng-hui, 2005.

<sup>56</sup> Yang Hsiu-hui, 2007.

<sup>57</sup> Chou Jun-hsiung et al., ca.1993.

infection in Taiwan.<sup>58</sup> In 1997, Show Chwan Hospital in Changhua conducted health examinations for 50,611 foreign laborers and found 0.3% of them were infected by *Opisthorchis viverrini*.<sup>59</sup> Moreover, at Meinung, Chenqing Lake澄清湖, Jinshi Lake金獅湖 and Lianchi Pond蓮池潭 in Kaohsiung County, a kind of snail, *Thiara granifer*, was found to be infected by *Opisthorchis viverrini*.<sup>60</sup> In a lecture delivered on 10 November 2001, Chen Eng-rin pointed out that *Opisthorchis viverrini* was a new factor of inducing liver cancer.<sup>61</sup> In June 2003, a kind of liver fluke originated in Southeast Asia was discovered from an old man at Tzuai Hospital at Xiluo西螺, Yunlin. This old man confessed that he liked to eat raw fish. It was possible that this fluke was introduced into Taiwan with foreign laborers and the fresh-water fishes were contaminated by excrements of these laborers.<sup>62</sup>

In short, although the infection of CS in Taiwan was under control since the 1990s, the opening of trade and traveling between Taiwan and the Mainland as well as entrance of foreign brides and workers also brought certain danger of new infection; particularly the appearance of *Opisthorchis viverrini* with the Thai laborers working in Taiwan should not be overlooked.

### 3. The Infection of *Clonorchis sinensis* in Mainland China

In Mainland China, the first report concerning the infection of CS appeared in 1908. Before 1930, studies were mostly done by Western medical doctors and scholars residing in China. During the Japanese colonial rule in Taiwan, the authority sent medical doctors to South China, and following the outbreak of Sino-Japanese War in 1937 the Taiwan Government-General also dispatched medical teams to Guangdong to take care of sanitary affairs.<sup>63</sup>

During 1988-1992, China conducted the first national investigation on parasitic diseases in 30 provinces (including self-governing areas and cities) with samples of 1,477,742 persons taken from 2,848 locations in 726 counties. Altogether 56 species of parasites were detected and CS, with infection distributed in 22 provinces, was one of the 15 most prevalent species. The total infection rate of CS was 0.365% with the highest rate of 1.824% discovered in Guangdong.<sup>64</sup> Taking 0.365% as a reference, some scholars estimated that there were more than 4.7 million persons infected in China, but some estimated that there were 10 million persons, of which 5 million were

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<sup>58</sup> Fan Ping-chin et al., 2001b.

<sup>59</sup> Chang Hui-ju et al., 1997.

<sup>60</sup> Yen Chuan-min et al., 2001.

<sup>61</sup> *Epoch Times*, 2001/11/10.

<sup>62</sup> *Epoch Times*, 2003/06/26.

<sup>63</sup> Gejiō, 1931; Taiwan Jihō, 1939.

<sup>64</sup> Yu Sen-hai et al., 1994a.

in Guangdong.<sup>65</sup>

During 2001-2004, another national investigation was conducted in 27 endemic provinces of *CS* with 211,500 samples taken from 423 locations in 141 counties (cities). The total infection rate at the endemic area was 2.40%; taking this rate as a reference it was estimated that the total number of persons infected was 12.49 million. The top five highest infection rates were found in Guangdong 16.42%, Guangxi 9.76%, Heilongjian 4.73%, Jilin 2.89%, and Chongqing City 1.18%.<sup>66</sup> With this background, details of infection in endemic areas will be presented below.

### **3.1 Guangdong Area (including Hainan and Hong Kong)**

In the first half of the twentieth century, most western medical doctors in China agreed that Guangdong Province, particularly Canton (Guangzhou) and Swatow (Shantou 汕頭), was the major endemic area of *CS*. Reports before 1950 showed that infection rates were mostly more than 30-40%.

Two earliest reports on *CS* infection in Guangdong both appeared in 1908: (1) The infection rate was 16.7% among 257 patients in Chaochow 潮州 and (2) The infection rate of the Cantonese patients was 36.3% (109/300).<sup>67</sup> In 1912, the infection rate of the patients at Hong Kong Civil Hospital was 13.25%.<sup>68</sup> In 1913, surveys among students of Canton Christian College and Normal School found the infection rate was 9.2% (7/76); and when the patients at the Medical School Hospital of Canton University were added, the infection rate was 13.3% (13/98).<sup>69</sup>

In the 1920s there were several surveys. In 1923, under the guidance of Faust, Chen Pang conducted fecal examinations among freshmen of Peking University and found that the infection rate of *CS* among students coming from Guangdong was 37.39%; and the rate of those from Canton and Swatow was respectively 51.9% and 43.7%. A similar survey in 1924 found the average rate was 41.93%.<sup>70</sup>

In the monograph published in 1927, Faust and Khaw summarized the results of surveys at three hospitals in Canton: (1) The infection rate at Canton Hospital was 20%; (2) The three years data of the Old and New Kung Yee Hospital showed the average rate was 16.25% (883/5434); and (3) The infection rate of in-patients at David Gregg Memorial Hospital was 3.17% (23/726). Faust also conducted surveys personally at the last two hospitals and found the average infection rate was 22.86%. Moreover, the infection rate was 20% among students and nurses at Hackett Medical

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<sup>65</sup> Zhou Ji-li et al., 2003.

<sup>66</sup> CONS, 2005.

<sup>67</sup> Whyte, 1908; Heanley, 1908.

<sup>68</sup> Bell, 1912.

<sup>69</sup> Cadbury, 1914.

<sup>70</sup> Faust, 1925b.

School. The American Baptist Mission had conducted surveys in Swatow and found the infection rate was 3.1% (10/323). They also pointed out that Chiehyang揭陽 and Chiaying嘉應 were endemic areas although no data were available.<sup>71</sup>

In 1927, Oldt reported results of investigations around Guangzhou in two parts. The first part concerning 12 locations at Siu Laam (Xiaolan小欖) where sericulture was prosperous. The infections rates ranged from 0 to 100% with an average of 37.5% (182/485). It was pointed out that the location with no infection was because those ponds were too dirty for snails to survive. The second part analyzed cases found in Canton Hospital with five groups of the patients as follows: (1) The infection rate was 31% (43/139) for those from Shan Tak (Shunde順德) where the people devoted entirely to sericulture; (2) The infection rate was 23% (77/342) for those from Heung Shan (Foshan佛山) and Nam Hoi (Nanhai南海) where sericulture counted for 30-50%; (3) The infection rate was 21% (130/606) for those from San Wui (Xinhui新會) and 17 other places where sericulture counted for only 10%; (4) The infection rate was 9% (23/266) for those from Toi Shan (Taishan台山) and other places where there was no sericulture; (5) The infection rate was 3.5% (14/394) for patients, chiefly soldiers, from Guangxi, Hunan, Yunan and other provinces. These groupings reflected a clear relationship between the infection rate of CS and the practice of sericulture with a combination of fish culture.<sup>72</sup> Moreover, from November 1927 to March 1928, the infection rate of the in- and out-patients at Hakuai Hospital in Canton was 48.96% (164/335).<sup>73</sup>

Analyses of the 1931-1935 records of Canton Hospital found the infection rate was 11.36% (458/4033) and the autopsy of 200 corpses revealed that 80% of them were infected.<sup>74</sup> In July 1939, the infection rate of residents in Haikou海口 and Qiongsan瓊山, Hainan Island, was 0.32% (1/312).<sup>75</sup> In 1939-1940, the infection rate in Guangdong was 15.85% (107/675) with a significant difference between male 20.0% (71/355) and female 11.25% (36/320).<sup>76</sup> Finally, a report in 1949 stated that the infection rate was 12.1% (89/735) among students in Hong Kong, and for patients at Canton Hospital for many years the rate was 10.15% (603/5939).<sup>77</sup>

Map 4 shows infection rates in Guangdong area after 1950. There were four surveys covering the entire province: (1) During 1971-1991, the infection rate was 16.2% (110176/680671), and the major endemic area was along the Peral River where the infection rates ranged from 62.9% to 84.8%; (2) In 1988, surveys at 31 counties

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<sup>71</sup> Faust and Khaw, 1927:124-141.

<sup>72</sup> Oldt, 1927.

<sup>73</sup> Ishii, 1928.

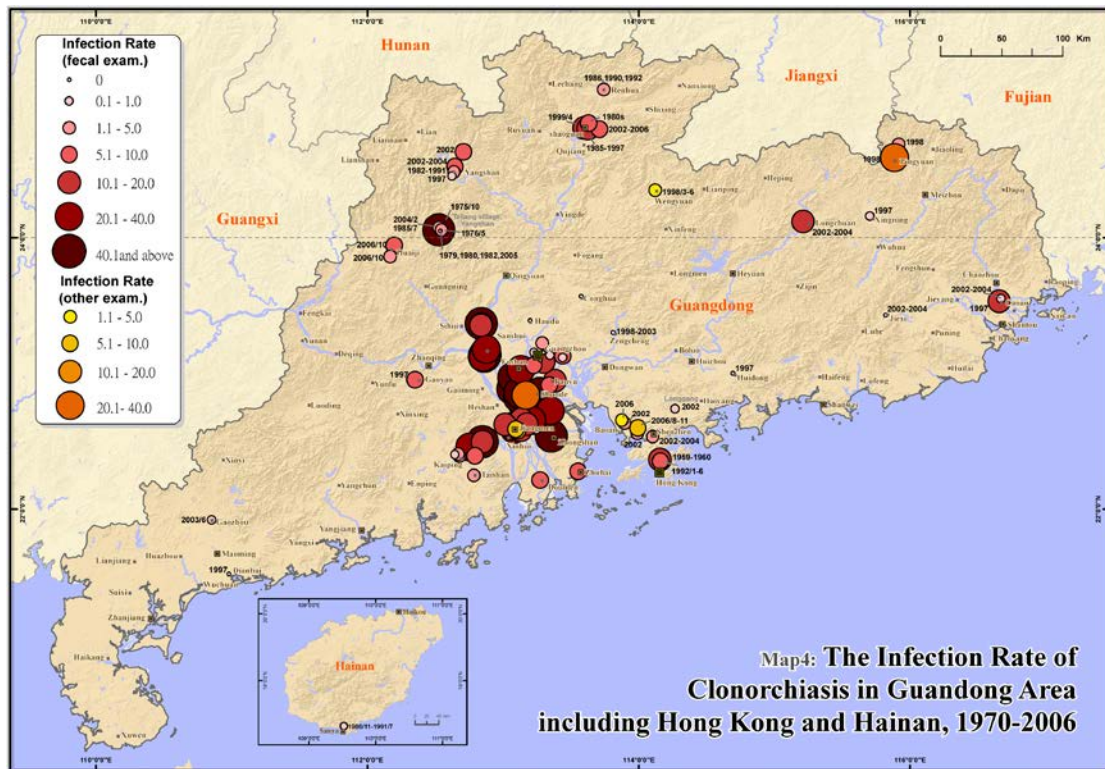
<sup>74</sup> Hsü and Chow, 1937:342.

<sup>75</sup> Kobayashi et al., 1940.

<sup>76</sup> Osaka, 1941.

<sup>77</sup> Wang Chiu-an, 1949.

(cities) found the infection rate was 1.8% (1122/61517); (3) In 1997, sample surveys at eight of the 31 counties (cities) investigated previously found the total infection rate was 4.1% (335/8217); the rates at different places were as follows: Chaoan潮安 17.69%, Gaoyao高要 7.00%, Doumen斗門 5.90%, Yangshan陽山 0.93%, Kaiping開平 0.19%, and Xingning興寧 0.09%, while Dianbai電白 and Huidong惠東 had no infection; and (4) In 2002-2004, sample surveys at 27 locations in 9 counties (cities) found the total infection rate was 16.42% (2278/13876); individually, the rates were: Shunde 50.74% (792/1561), Zhongshan中山 41.73% (626/1500), Jiangmen江門 27.17% (416/1531), Longchuan龍川 14.05% (218/1552), Yangshan 6.44% (97/1506), Zhuhai珠海 5.89% (88/1494), Shenzhen深圳 1.56% (26/1666), Chaoan 0.99% (15/1504), and Jiexi揭西 had no infection (0/1562).<sup>78</sup>



Map 4: The Infection Rate of Clonorchiasis in Guangdong Area including Hong Kong and Hainan, 1970-2006

Along the Pearl River, investigations were conducted in Guangzhou, Sanshui, Zhaoqing, Shunde, Zhongshan, Jiangmen, Kaiping, Taishan and Shenzhen. During 1998-2003, the infection rate of residents in Guangzhou was 6.6% (1871/28376). Among districts, the highest rate, 14.9% (1597/10715), was found at Panyu番禺 and among occupations, the highest rate, 9.31% (1841/19774), was found among

<sup>78</sup> OLC, 1995:123; Fang Yue-yi et al., 2000; Pan Po et al., 1998; Fang Yue-yi et al., 2007.



farmers.<sup>79</sup> Some districts in Guangzhou had local surveys. At Panyu, the infection rate of three villages was 9.6% (161/1674) in 1988, but it was 16.9% (268/1583) in 2002; there was an increased of 76 percent.<sup>80</sup> At Fangcun芳村, the infection rate of eight villages was 5.1% (192/3762) in 1998-2003, and that of the two urbanized villages was 1.2% (14/1206). The lower rate at urbanized villages reflected that the living environment had been improved.<sup>81</sup> At Haizhu海珠, the infection rate of civil servants was 11.3% (43/382) in 2005, and there was a significant difference between male 15.0% (37/246) and female 4.4% (6/136).<sup>82</sup> At Huangpu黄埔, the total infection rate of occupational groups was 7.71% (42/545) in 2006, and there was a significant difference between male and female as well as among occupational groups.<sup>83</sup>

Sanshui, located at northern part of the Pearl River Delta, had surveys at Dongyong董永 in 1986-1988 and at Guanyuan官元 in 1990-1992. Both districts had devoted to fish culture by feeding fishes with feces flowing from latrines built on top of fish ponds. At Dongyong, the infection rate in 1986 was 43.6% (297/681) but after adopting measures of prevention and control, the rate was reduced to 14.5% (213/1465) in 1987 and to 13.2% (204/1551) in 1988. At Guanyuan, the infection rate in 1990 was 78.5% (898/1144), but after prevention and control it was reduced to 53.0% (543/1025) in 1991 and to 36.3% (207/570) in 1992. The results indicted the effect of curing with Praziquantel.<sup>84</sup> Moreover, in 1996, the enzyme-linked immunosorbent assay (ELISA) method was adopted to examine workers of catering trade and staffs of enterprises and found the positive rate was 29.9% (4498/15034); there was a significant difference between male and female as well as among groups of workers.<sup>85</sup>

Zhaoqing, located in northwestern part of the Pearl River Delta, had an abundant resource of fresh-water fish. Fecal examinations conducted for in- and out-patients at the People's First Hospital during 2001-2004 found the total infection rate was 7.2% (4906/68446). It was noted that the rate was increasing from 5.4% (922/17045) in 2001, to 6.1% (994/16411) in 2002, to 7.7% (1154/15025) in 2003, and to 9.2% (1836/19965) in 2004.<sup>86</sup>

Shunde, located at the middle of the Pearl River Delta, had more than 200,000 *mu* (6.6 *mu* = 1 acre) of fish ponds which provided conditions for CS to propagate. Suverys during 1982-2000 found the total infection rate was 59.5% (4862/8171). Residents at different places were investigated in different years with different

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<sup>79</sup> Feng, Yue-ju et al., 2004b.

<sup>80</sup> Zeng Rui-zhi, 2003; Liu Xiao-ning et al., 2000; 2003; Feng Yue-ju et al., 2004a.

<sup>81</sup> Yang Li-li et al., 2004.

<sup>82</sup> Zhao Li-qing et al., 2006.

<sup>83</sup> Huang Yu et al., 2007.

<sup>84</sup> Zou Hui-ning et al., 1994.

<sup>85</sup> Cai Wen-an et al., 1999.

<sup>86</sup> Ou Hui-mei et al., 2006.

methods but the rates of infection were all rather high: 43.1% (457/1061) in 1982, 67.5% (3179/4709) in 1995, 54.4% (154/283) and 45.5% (582/1280) in 1996, and 58.6% (491/838) in 2000.<sup>87</sup> In 2001, the ELISA method was adopted to investigate workers and found the positive rate was 29.8% (1182/3966).<sup>88</sup> Moreover, a survey at Guizhou桂洲 district in 1994 found the infection rate was 54.6% (805/1473).<sup>89</sup> Another survey at Gulang古朗 village in 2003 found the infection rate was 47.2% (513/1088).<sup>90</sup>

Around 2005, Foshan conducted health examinations for employees newly arrived from outside of the city and found the positive rate was 1.96% (11/562) by the ELISA method, but the rate was somewhat higher for those who had lived in the city for more than 3 years. In February-March 2006, the Kato-Katz method was applied to examine the residents and found the infection rate was 23.13% (263/1137). The infection rate in Foshan was still rather high because no measure of control had been adopted and a larger amount of raw fish was consumed following the improvement of living standard.<sup>91</sup>

Zhongshan, located in the south of Shunde, had 2 investigations. In May 1996, the infection rate of residents at Guzhen古鎮 was 12.5% (143/1144). From June to September 2000, surveys at three villages of three townships found the total infection rate was 41.7% (625/1500). It was noted that at Tongan Village同安村 with the rate of 46.8% (234/500), which was higher than the average, the raw-fish gruel was provided by almost all eating houses in the village.<sup>92</sup>

Jiangmen, located in mid-west part of the Pearl River Delta, had conducted 6 investigations: (1) In 1989, the infection rate of residents at three towns was 4.2% (108/2576); (2) In 1989-1992, the infection rate of cadres and workers was 31.4% (1653/5262); (3) In 1994, the ELISA method was applied and found the positive rate of elementary school pupils was 3.7% (383/10398), middle school students 6.6% (477/7252), and high school students 7.6% (457/6009); (4) In 2002, the three towns examined in 1989 had the second round investigation and found that the infection rate was 27.2% (416/1530), which was much higher than before; (5) In 2003-2004, the ELISA method was applied to examine new students of middle schools, cadres and workers; it was found that the positive rate of students was 8.6% (652/7581), of cadres and workers 11.9% (498/4186); and (6) In 2004, investigations of different occupational groups found the total infection rate was 16.3% (881/5404), the rate of

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<sup>87</sup> Ma Jian-qiang et al., 2001; Liang Wen-jia et al., 2001.

<sup>88</sup> Su Hui-ye et al., 2002.

<sup>89</sup> Fang Yue-yi et al., 1996.

<sup>90</sup> He Jian-ping, 2004.

<sup>91</sup> Su Hui-ye et al., 2006; Liang Zhi-liang et al., 2007.

<sup>92</sup> Feng Qiang et al., 1997; 2004.

cadres was 20.6% (412/1998) and workers 18.6% (113/606).<sup>93</sup> In addition, at Siqian Town 司前鎮 of Xinhui District 新會區, infection rate was 12.1% (61/503) in 1989 and 50.3% (255/507) in 2002. The increase also reflected that CS infection tended to have family clusters.<sup>94</sup>

Kaiping, located at the southwest of the Pearl River Delta, had an infection rate of 1.6% (33/2031) in 1989 and 4.4% (67/1516) in 2002. The increase also reflected that eating raw fish had become more popular and no measure of control was adopted so far. Shuikou Town 水口鎮, located in the east of Kaiping, had an infection rate of 5.3% (27/508) in 1989 and 11.2% (56/500) in 2002. Additional surveys at two villages of this town in December 2002 found the infection rate was 34.1% (377/1105). Similar to cases mentioned above, the increase was related to the popularity of eating raw fish along with the improvement of economic conditions.<sup>95</sup>

Taishan, located at southwest coast of Guangdong, had a large number of fish ponds. In 2006, surveys among residents who had not taken any cure within one month found that the infection rate was 6.8% (100/1479) at two towns. Comparatively, Taishan was a low endemic area of CS, but the practice of building latrines along fish ponds and the habit of eating raw fish were still quite popular.<sup>96</sup>

Shenzhen, located at southeast coast of Guangdong, had the first survey in June 2002 for residents at three districts and found the infection rate was 1.19% (6/506) at Baoan 寶安, 2.47% (16/647) at Nanshan 南山, and 0.96% (5/513) at Longgang 龍崗. From August to November 2006, surveys at Nanshan for the staffs of enterprises found the infection rate was 5.77% (299/5185). In the same year, another survey at Baoan found the infection rate was 4.78% (71/1487). It was reported that the practice of building latrines and pigpens along fish ponds was promoted since the late 1980s and still in operation at the time of investigation. Moreover, in July 2005 the infection rate in Shenzhen was 8% (240/3000). These reports all pointed out that the infection rate of CS was increasing while that of other parasites was declining following the modernization in Shenzhen.<sup>97</sup>

Hong Kong, located in the south of Shenzhen, had an infection rate of 17.7% in 1959-1960. From January to June 1992, fecal examinations of residents found the infection rate was 5.3% (453/8590). It was noted that the decrease of CS infection was slower than other parasites because the people of Hong Kong could not easily give up the habit of eating raw fish.<sup>98</sup>

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<sup>93</sup> Zhou Yue-liang et al., 2005; Zhou Chun-hong et al., 1995; 1997; Cai Hui-xia et al., 2005; Li Feng-ling et al., 2005a.

<sup>94</sup> Chen Ri-nuan et al., 2003; Nie Xin-qiang, 2005.

<sup>95</sup> Situ Rong-ruan et al., 2004; 2005; Wu Song-run et al., 2004.

<sup>96</sup> Liu Wen-jin et al., 2007.

<sup>97</sup> Zhang Xiao-lan et al., 2004; Dai Chuan-wen et al., 2007; Liu Yi et al., 2007; CRI on line, 2005.

<sup>98</sup> Huang Zhi-ping, 1995.

Beyond the Pearl River Delta, Gaozhou高州, located in the southwest of Guangdong, the infection rate was 0.26% (4/1532) in June 2003. It was noted that these 4 sufferers of CS had eaten raw fish while traveling at other endemic areas.<sup>99</sup>

In northern Guangdong, data were available in Pingyuan平遠, Wongyuan翁源, Renhua仁化, Shaoguan韶關, and Yangshan陽山. In 1998, a survey at Batou Town 壩頭鎮 in Pingyuan proceeded in two steps: intradermal tests were taken first, and then the positive cases were followed up with fecal examinations. The result showed 4.2% (4/95) of multiple infections of *Clonorchis sinensis* and *Metorchis orientalis*; it was noted that *Metorchis orientalis* was discovered for the first time in China in this investigation.<sup>100</sup>

In Wongyuan, the rapid indexing method was adopted to examine elementary and middle school students from March 30 to June 10 in 1998 and found the infection rate was 4.0% (368/9294). The reason for the infection among students in this county was because latrines were built on top of ponds and children also liked to eat raw or half-cooked fish and shrimp. (Liu Xiao-ming., 1999) In Renhua County, surveys in 1986, 1990, and 1992 found the total infection rate was 4.2% (143/3418).<sup>101</sup>

Shaoguan had several investigations: (1) In 1980, the infection rate at suburb was 6.9%; (2) Investigations during 1985-1997 in the city found the average rate was 15.3% (886/51445); an increasing trend was observable as the rate increased from 7.0% in 1985 to 21.3% in 1997; (3) In April 1999, residents of Xianyang Village向陽村 received fecal examinations and the infection rate was 13.9% (76/546), which was two times higher than that of 1980; (4) During 2002-2006, at Zhenjiang滇江district, located along the upper Peral River, where more fish ponds had been created after the reform in the 1980s, the infection rate was 8.8% (290/3301).<sup>102</sup>

Yangshan also had several investigations. (1) In 1982-1991, infection rate of residents at 10 towns and the staffs of county offices was 2.1% (2188/106887). It was reported that during the period of Sino-Japanese War, refugees from Nanhai, Panyu and Shunde came to settle at Yangshan and brought with them the custom of eating raw fish. Some sufferers denied that they had the habit but it was possible that their food was contaminated by unclean chopping block. (Huang Xin-hua et al., 1994) (2) Around Dalang Village大莨村, located in the mountain area of Yangshan, there were small ditches and a fish pond in front of the village. The villagers used to drink the water taken from ditches but they did not eat raw fish nor had the practice of feeding fish with feces. During 1975-2005, several surveys found that the infection rate was 48.3% (69/143) in 1975, 2.9% (4/138) in 1976, no infection in 1979, 1980, and 1982,

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<sup>99</sup> Liu Tu et al., 2005.

<sup>100</sup> Lin Jin-xiang et al., 2001.

<sup>101</sup> Zhang Nan-chun, 1994.

<sup>102</sup> Liu Tian-lai, 1988; Li Shi-fu et al., 2000; Xie Xiao-bin, et al., 2000; Zou Xue-hai et al., 2007.

and 1.3% (2/159) in 1985, 1.1% (1/92) in 2004, and again no infection in 2005. The declining infection rate was because measures of control were adopted extensively. (Luo Xiong-cai et al., 2005) (3) In 2002, random surveys at three villages in east, south, and north of Yangshan County found the total infection rate was 6.5% (98/1511). Of these 98 sufferers, 90 were found at Xingang Village新崗村 in the south and 83 of them had experiences of eating raw fish. Moreover, the practice of feeding fishes with feces was also popular in this village.<sup>103</sup>

Huaiji County懷集縣, located in northwestern Guangdong, had a survey in 2006 at two towns and found the infection rate was 3.34% (47/1409). Although the infection rate was low, it should not be ignored that residents of this county had acquired the habit of eating raw fish in recent years.<sup>104</sup>

Finally, in Hainan Island, random surveys from November 1986 to July 1991 at five cities found the infection rate was 0.4% (32/7958). It was pointed out that previous studies had suggested that the infection of *CS* prevailed only in the north of 22°N, but the 32 cases found in these surveys were all distributed around 18°N; whether this would be the southern end of endemic area of *CS* in China required further studies.<sup>105</sup>

### 3.2 Guangxi

In Guangxi, Vickers reported that in 1914, the infection rate of *CS* was 12.67% (19/150) among patients of Wesleyan Hospital in Wuzhou梧州.<sup>106</sup> In 1938, some cases of infection were discovered among farmers in Binyang賓陽.<sup>107</sup> Since the 1980s, Guangxi had several general investigations with the following results. (1) In 1985, it was estimated that 12.23 million people of 32 counties and cities in Guangxi were threatened by *CS* infection. (2) In 1988-1989, the average infection rate of 20 counties was 1.2% (623/51883) with the highest rate, 44.2%, found in Fusui扶綏. (3) In 1990, the total infection rate was 21.8% (20318/93020) at 55 villages in 25 counties. (4) In 1990-1997, the total infection rate was 20.2% (22663/112444) at 135 locations in 44 counties; and the rate of the 33 counties to the south of latitude 24 degree was much higher than the 11 counties in the north; i. e., 21.0% (21760/103693) vs. 10.3% (905/8751). (5) In 2002-2004, the infection rate was 9.8% (1365/13990) at 27 locations in 9 counties.<sup>108</sup>

Because the locations investigated at each time were different, it is difficult to

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<sup>103</sup> Huang Xin-hua et al., 2005.

<sup>104</sup> Mo Hai-ying, 2007.

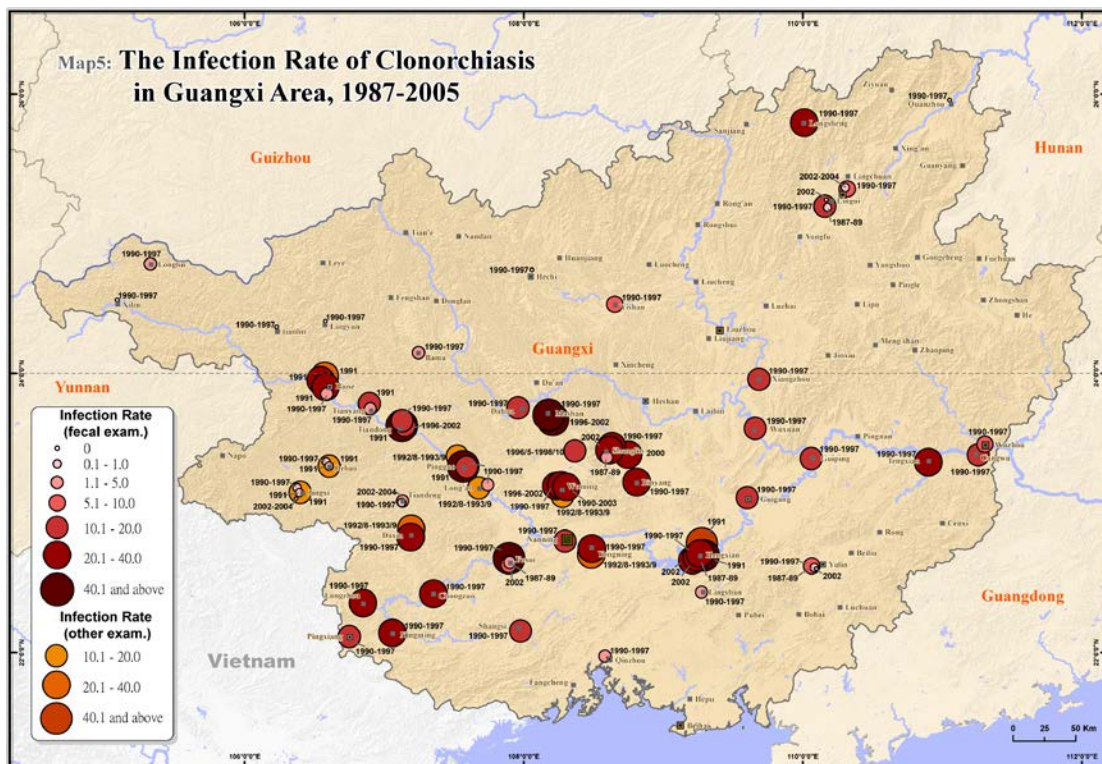
<sup>105</sup> Xu Feng-shui et al., 1994.

<sup>106</sup> Vickers, 1916.

<sup>107</sup> Li Shu-lin et al., 2002.

<sup>108</sup> Ruan Ting-qing et al., 2005; Shang Shao-ming et al., 1994; Li Shu-lin et al., 1995; 2002; Zhang Hong-man et al., 2005.

make a correct comparison over time. But all reports agreed that in Guangxi, the area in the south of latitude 24 degree provided suitable conditions for the infection of *CS* because of the warm weather, abundant rainfall, lots of rivers, and rich in fresh-water fish, as well as the habit of eating raw fish and improper management of excrements in rural area. The higher infection rate was usually found in rich places with sufferers clustered in rich families. Moreover, the endemic areas had extended to the north of 24°N according to the results of the 2004 investigation.<sup>109</sup> Map 5 shows the major infection rates in Guangxi after 1980.



Map 5: The Infection Rate of Clonorchiasis in Guangxi Area, 1987-2005

There were five counties where data were available in both 1987-1989 and 2002 surveys: respectively, Hengxian横縣 had 14.4% (378/2623) and 28.8% (504/1748), Shanglin上林 had 3.6% (97/2695) and 29.1% (433/1488), Fusui had 3.3% (71/2159) and 7.2% (110/1520), Yulin玉林 had 0.6% (16/2547) and 0% (0/1531), and Lingui臨桂 had 0.2% (5/2543) and 0% (0/1650). The total infection rate was respectively 4.6% (576/12567) and 13.2% (1047/7973); there was an increase of 187 percent. Moreover, during 1996-2002, surveys in five high endemic counties found that the total infection rate was 33.0% (2209/6697); among the five counties, Mashan馬山 had 72.6% (579/798), Wuming武鳴 34.4% (383/1114), Shanglin 29.1% (433/1488),

<sup>109</sup> Ruan Ting-qing, 2004.

Hengxian 28.8% (504/1748), and Tiandong田東 20.0% (310/1549).<sup>110</sup>

In 1991, investigations at nine counties along the You River右江 in the autonomous region of Zhuang 壯 people found that at locations close to the river, the positive rate by intradermal tests was 26.3% (4792/18246) and the infection rate by fecal examinations was 38.8% (1424/3661). The infection rate of each county (city) was as follows: Tiandong 46.8% (938/2008), Pingguo平果 46.6% (349/742), Baise 百色 22.6% (14/62), and Tianyang田陽 14.5% (123/849). At locations away from the river the infection rates were much lower: Baode德保 0.2% (1/524), Jingxi靖西 0.3% (2/714) and the other three counties had no infection. (He Gang et al., 1994) In October 1991, the SPA (Staphylococcal Protein A)-Dot-ELISA method was adopted in Hengxian and found the positive rate was 42.1 % (482/1144), and there was a very significant difference between male 58.6% (343/585) and female 9% (139/559). Moreover, among those who received both serum and stool examinations, the positive rate was 46.2% (174/377) and the infection rate was 45.1% (170/377). These results showed no difference of the two methods, but the SPA-Dot-ELISA method was easier to apply and had a higher sensitivity.<sup>111</sup>

From August 1992 to September 1993, the Fast-ELISA method was adopted to examine cadres and workers in five counties and found the positive rate was 17.5%; the rate of each county was in the order of Yongning邕寧 29.5%, Daxin大新 20.2%, Wuming 19.8%, Longan隆安 13.5%, and Pingguo 11.1%.<sup>112</sup>

During 1990-1997, investigations in 44 counties, of which 33 were in the south of 24°N, found that there were six counties with infection rates above 30%: Mashan 74.8% (597/798), Fusui 40.3% (349/866), Tengxian藤縣 31.9% (155/486), Wuming 31.9% (1459/4575), Daxin 31.0% (141/455), and Yongning 30.9% (615/1989). Another six counties had the infection rates of 20-30%: Binyang 28.9% (3376/11667), Shanglin 27.9% (57/204), Longzhou龍州 27.2% (120/442), Chongzuo崇左 26.1% (242/928), Hengxian 25.0% (10746/42987), and Ningming寧明 21.0% (161/766). There were 11 counties with the infection rates of 10-20%: Nanning南寧 17.4% (95/545), Pingxiang憑祥 16.9% (108/637), Cangwu蒼梧 16.4% (231/1410), Dahua大化 15.8% (153/966), Wuxuan武宣 15.6% (270/1728), Guiping桂平 15.2% (403/2645), Guigang貴港 12.8% (390/3057), Pingguo 11.5% (747/6512), Tiandong 10.5% (938/8928), Xiangzhou象州 10.4% (87/837), and Shangsi上思 10.3% (65/632). And there were 10 counties with infection rates below 10%: Wuzhou 8.5% (47/553), Yulin 8% (12/206), Lingshan靈山 4.0% (15/376), Baise 3.8% (14/373), Tiandeng天等 3.4% (16/471), Tianyang 2.6% (123/4721), Longan 2.4% (16/681), Qinzhou欽州 2.0% (9/450), Jingxi 0.3% (2/711), and Debao 0.1% (1/1091). Among

<sup>110</sup> Ruan Ting-qing et al., 2005.

<sup>111</sup> Lu Chuan et al., 1994.

<sup>112</sup> Fang Zhong-liao et al., 1996.

the 11 counties in the north, the highest rate was found in Longsheng 龍勝, 36.6% (758/2146), ranked the third in the province, while the rates in other counties were in the order of Lingui 臨桂 10.1% (85/839), Guilin 桂林 8.1% (20/246), Yizhou 宜州 5.1% (26/513), Longlin 隆林 3.8% (14/368), and Bama 巴馬 1.7% (2/120). There was no infection in Chuanzhou 全州, Linyun 凌雲, Hechi 河池, Xilin 西林, and Tianlin 田林, because they were located in the mountain area where there was few fish ponds.<sup>113</sup>

In 2002-2004, investigations in nine counties found the total infection rate was 9.8% (1365/13990). The rate of each county was as follows: Shanglin 29.1% (433/1488), Hengxian 28.8% (503/1748), Tiandong 20.1% (311/1549), Fusui 7.2% (110/1520), Tiandeng 0.4% (6/1501), and Guilin 0.1% (2/1495), while no infection was found in Lingui (0/1650), Yuling (0/1531), and Jingxi (0/1508). As for the infection rates of different ethnic groups, they were in the order of Monggol 16.7% (4/24), Hui 11.8% (2/17), Han 11.6% (847/7330), Zhuang 8.2% (501/6131), Yao 1.8% (8/458), and others 10.0% (3/30).<sup>114</sup>

Some local survey data were also available. At Liangjiang Town 兩江鎮 of Wuming county, the infection rate among students was 14.7% (44/300) and that of residents at 10 towns and 2 farms was 28.1% (10036/35698) in 1996-1998. It was noted that higher infection rates were discovered with the people of higher income.<sup>115</sup> At Baiyu Town 白圩鎮 of Shanglin county, a survey found the infection rate was 38.4% (195/508) around the year 2000.<sup>116</sup> And around 2002, a joint investigation by Chinese and Japanese scholars at three towns in Hengxian found the infection rate was 31.6% (491/1552). Compared with the infection rate of 18% in 1989, there was an increase of 76 percent.<sup>117</sup>

The section of Litang-Nanning-Pingxiang 黎塘-南寧-憑祥 along the Nanning Railroad, a length of 340 kilometers, located in the middle south of Guangxi where Zuo 左, Yong 邕, and Yu 郁 Rivers form a network is an endemic area of CS. In November 2005, an investigation with all staffs and workers of this railroad section found the infection rate was 47.0% (393/836); there was a significant difference between the male 50.8% (390/768) and female 4.4% (3/68). Classified by residential places of these staffs, the infection rate to the north of Nanning city was 67.6% (69/173), in the city 44.0% (208/473) and to the south 35.3% (66/187). Classified by family monthly income in terms of Renminbi, the rate was 39.9% (69/173) for those below 500 yuan, 48.5% (249/513) for those 500-800 yuan, and 50.0% (75/150) for

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<sup>113</sup> Li Shu-lin et al., 2002.

<sup>114</sup> Zhang Hong-man et al., 2005.

<sup>115</sup> Tan Quan-ji et al., 2001; Su Lin-jun et al., 2006.

<sup>116</sup> Li Xue-ming et al., 2001.

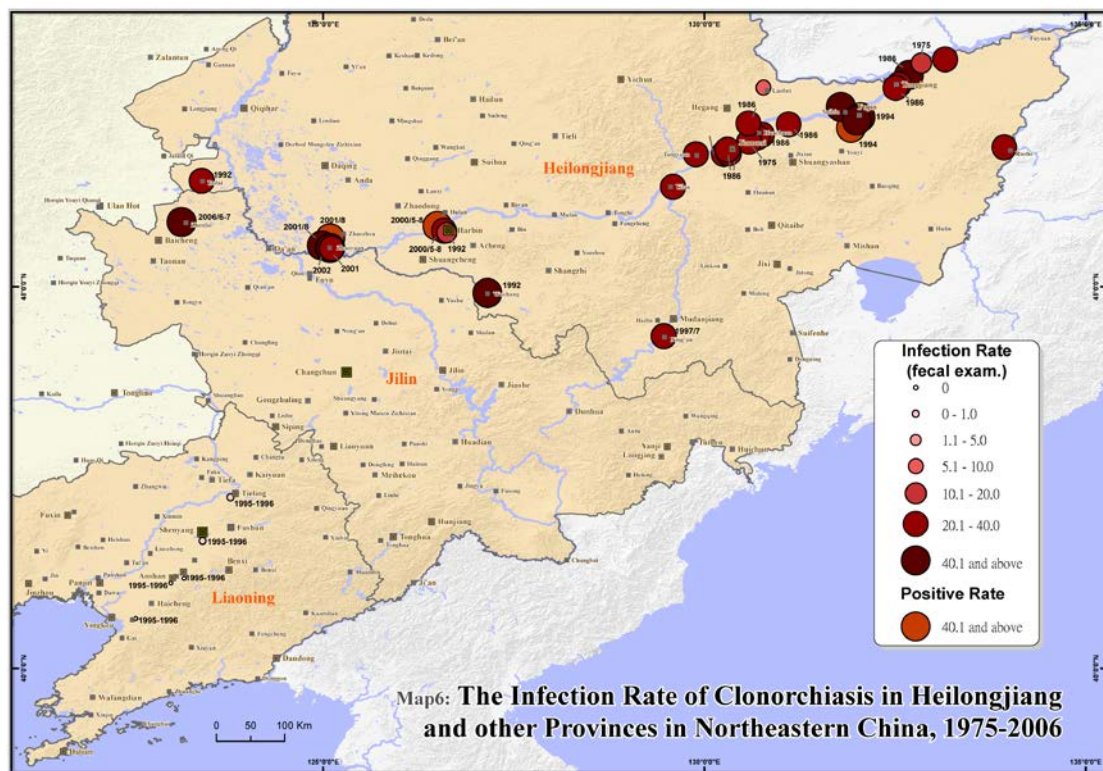
<sup>117</sup> Yu Sen-hai and Masanori Kawanaka, et al., 2003.



those above 800 yuan. Classified by the habit of eating fish, the rate for those eating raw fish was 67.3% (373/554), for those eating half-cooked fish was 8.5% (10/118), and for those eating cooked fish was 6.1% (10/164). These results reflected significant differences in terms of habit, residence, income, and gender.<sup>118</sup>

### 3.3 Heilongjiang and the Northeast China

As mentioned above, the national investigations during 2001-2004 found that the infection rates of CS in Heilongjiang and Jilin ranked the third and the fourth. It is notable that not only Korean but other ethnic groups living in Heilongjiang have the habit of eating raw fish. Map 6 shows the distribution of CS infection in Northeast China.



Map 6: The Infection Rate of Clonorchiasis in Heilongjiang and other Provinces in Northeastern China, 1975-2006

In 1975, the first investigation of CS in Heilongjiang was conducted at Jiamusi 佳木斯 and found the infection rate of Korean was 29.4% and that of Hezhe 赫哲 16.9%. In 1981, it was reported that of the 13 rivers in this province, the infection rate along the Songhua (Sungari) River 松花江 was the highest (29.5%).<sup>119</sup> In 1983, a

<sup>118</sup> Li Ge-ming et al., 2006.

<sup>119</sup> Li Xiong-hao, 1981.

survey along the Xibei River 西北河, a branch of the Songhua River, found that Korean living in Tonghe 通河 County had the positive rate of 34% by intradermal tests and the infection rate of 45.7% by fecal examinations.<sup>120</sup> Since 1986 surveys along the Songhua River found the infection rate of residents, mostly Han but also a small number of Korean and Hezhe, was 30.5% (1611/5275); the result proved that in this area the Han people also liked to eat raw fish just as Korean and Hezhe.<sup>121</sup> Moreover, Fujin 富錦 City, located on the southern bank of lower Songhua River, was a high endemic area. Surveys by 1994 among the Han staffs of many offices found the positive rate was 77.4% (587/758) and the infection rate was 54.7% (350/640).<sup>122</sup>

From August 1992 on, investigations in 26 counties and cities in Heilongjiang found the total infection rate was 1.2% (626/52131), but some counties had more than 15% and the highest rate was 44%. Investigations at farms in Wuchang 五常 and Tailai 泰來 Counties found the infection rates were respectively 59.0% (36/61) and 34.1% (116/339). (HDHP, 1995) Moreover, it was found that the infection rate of staffs at a port office in Haerbin 哈爾濱 was 11.6% (8/69).<sup>123</sup>

In July 1997, surveys among Korean residents at two villages in Ning'an 寧安 City where there were many ditches and ponds, found the infection rate was 37.9% (115/303), and of the 115 sufferers, 106 (99.2%) had experiences of eating raw fish.<sup>124</sup> During May-August 2000, surveys at two villages in Shangzhi 尚志 and Wuchang 五常 Counties under the jurisdiction of Haerbin City found the positive rate was 55.2% (277/502) and the infection rate was 23.5% (65/277).<sup>125</sup>

Zhaoyuan County 肇源縣, located at intersection of the Songhua River and the Nen 嫩 River, was a high endemic area of CS. In April-May 2001, at 10 villages in four rural townships, random samples of 2,400 persons were selected from 26,367 villagers aged 5-81, and found the infection rate by fecal examinations was 78.66% (1726/2194), which was higher than 61.7% (682/1094) found in 1985.<sup>126</sup> In August 2001, surveys at two villages in Yongli Rural Township 永利鄉 found that the positive rate was 56.9% (120/211) and the infection rate was 68.0% (119/175). The villagers who had experiences of eating raw fish accounted for 87.7% of sufferers and they often used the same chopping block to cut fish and other food.<sup>127</sup> In 2001, the infection rate at six villages was 57.3% (6929/12101) and in 2002, the infection rate at four villages was 31.9% (2464/7725). At the four villages where the villagers received examinations twice showed that the infection rates had declined and this reflected the

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<sup>120</sup> Xu Zhi-jie et al., 1983.

<sup>121</sup> Zhang wen-yu., 1994.

<sup>122</sup> Huang Xien-fang et al., 1995.

<sup>123</sup> Wu Xue-ling et al., 2000.

<sup>124</sup> Li Shun-yu et al., 2000.

<sup>125</sup> Niu Hong et al., 2001.

<sup>126</sup> Wang Li-gong et al., 2001.

<sup>127</sup> Zhao Hai-long, 2002.

effect of curing during the interim.<sup>128</sup>

By 2002, several investigations were conducted at 10 locations along the lower reaches of Songhua, Heilong and Wusuli烏蘇里Rivers, and the total infection rate was 31.5% (2841/9016). The infection rate of each location was as follows: Suibin綏賓 66.9% (123/184), Fujin 46.2% (350/758), Tongjiang同江 (including Hezhe people) 39.5% (747/1891), Ilan依蘭 (Korean) 38.1% (216/567), Huachuan樺川 30.8% (481/1560), Raohe饒河 28.9% (215/743), Tangyuan湯原 27.4% (271/988), Jiamusi 24.1% (338/1396), Qindeli勤得利 21.1% (52/246), and Lobei蘿北 (Korean) 7.0% (48/690). These rates were all much higher than the average rate of 1.2% obtained in the first province-wide investigation in 1992.<sup>129</sup>

In Liaoning Province, a report in 1958 said that cases of *CS* infection were found at Tieling鐵嶺. In 1981-1982, a survey of 1,780 Korean residents at Manrongtun滿融屯 in the suburb of Shenyang 瀋陽 found the infection rate was 9.4%.<sup>130</sup> The situation of infection in Liaoning became clear by 1984, but there was no further information afterwards. It was until 1995-1996 that an investigation was conducted again and found the total infection rate was 0.4% (60/14390); individually, Shenyang had 0.8% (55/7271), Tieling 0.2% (5/3312), and Anshan (0/2132), Liaoyang (0/251), and Yingkou (0/1424) had no infection. Among the Han, Manchu, and Korean residents, only Korean had an infection rate of 0.75% (601/8006). This investigation also pointed out that many small rivers were polluted and thus people avoided eating feral raw fish and thus the infection rate decreased.<sup>131</sup>

In Jilin Province, in June-July 2006, surveys at nine villages found the total infection rate was 44.50% (251/564).<sup>132</sup> This rate was much higher than the rate of 2.89% found in the 2002-2004 national survey.

### 3.4 Other Provinces in South China

Besides Guangdong and Guangxi where the infection rates of *CS* ranked on the top in national surveys, the infection rates of other provinces in South China were still quite notable as shown in Map 7. In below, situation in each province is presented separately.

#### (1) Fujian

In Fujian, John Preston Maxwell, the eldest son of J. L. Maxwell, reported in 1921 that he had collected data in the past 20 years in southern Fujian and found the

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<sup>128</sup> Ge Tao et al., 2003.

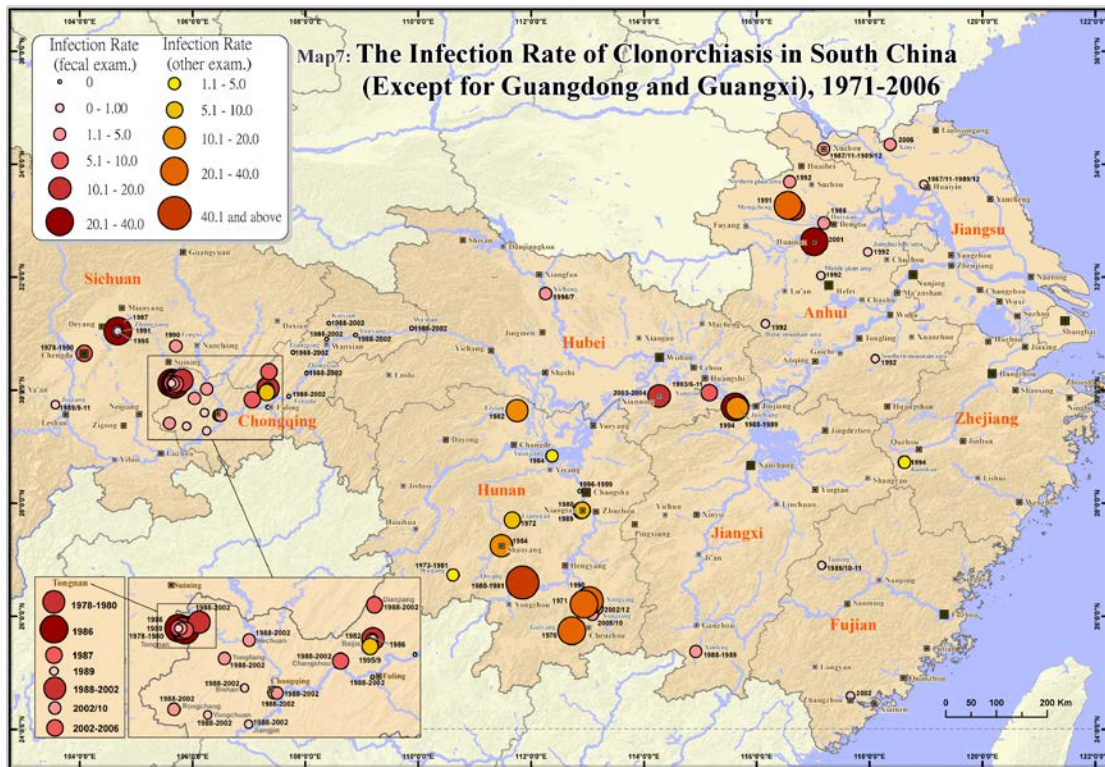
<sup>129</sup> Cai Lian-shun et al., 2002.

<sup>130</sup> Feng Lan-bin et al., 1983.

<sup>131</sup> Xu Jing-tian et al., 1998.

<sup>132</sup> Gao Ru et al., 2007.

residents were suffered with nine species of parasites, but not CS.<sup>133</sup> In 1929-1930, Ishii Shintaro and Cheng De-he conducted fecal examinations for in-patients of Hakuai Hospital in Amoy and found the infection rate was 0.95% (6/634), and five of the six sufferers had travelled to Canton and Hong Kong and ate raw fish there.<sup>134</sup>



Map 7: The Infection Rate of Clonorchiasis in South China (Except for Guangdong and Guangxi), 1971-2006

In October-November 1989, surveys at four villages in Taining 泰寧 County found the infection rate was 0.4% (8/2032).<sup>135</sup> In 1999, a hospital in Amoy discovered three cases of infection.<sup>136</sup> In 2002, investigations at nine villages around Zhangzhou 漳州 found the infection rate was 0.4% (20/4664).<sup>137</sup> And in 2005, a group of five tourists from Ningde 寧德 visited Nanning, Guangxi, and ate raw fish twice there. After returning they felt unwell and were diagnosed as infected by CS.<sup>138</sup>

## (2) Zhejiang

In 1924, Faust and Balow mentioned that the infection of CS in Zhejiang was

<sup>133</sup> Maxwell, 1921.

<sup>134</sup> Ishii and Cheng, 1931.

<sup>135</sup> Cheng You-zhu et al., 1994.

<sup>136</sup> Yang Wen-chuan et al., 2000.

<sup>137</sup> Xu Guo-fang et al., 2003.

<sup>138</sup> Li Yan-rong et al., 2006.

not as serious as in other provinces of South China.<sup>139</sup> In August 1994, a sufferer of Clonorchiasis received treatment at the People's Hospital in Jiangshan 江山 City and thus a survey was conducted at the village where this patient resided. It was found that by intradermal tests the positive rate was 3.0% (4/132) and by fecal examinations the infection rate was 2.9% (1/35). It was also found that the villagers were accustomed to eat half-cooked fish and this was the reason for their infection.<sup>140</sup>

### **(3) Jiangsu (including Shanghai)**

In Jiangsu, the earliest report by Jeffreys and Day concerning the cases at St. Luka's Hospital in Shanghai said that the infection rate was 0.4% (2/500) in 1907. Day reported again that the infection rate at the same hospital was 1.0% (1/100) in 1908.<sup>141</sup> In 1915, it was reported that 128 cases were discovered in Shanghai and the infection rate was 6%.<sup>142</sup> In 1935, it was reported that in Shanghai, the infection rate of elementary school pupils was 1.81%, middle school students 2.41%, vocational school students 5.09%, and the restaurant workers 7.18%.<sup>143</sup> During 1928-1933, the Pathology Department of Shanghai Medical School performed autopsy on 300 corpses and found CS in 2 Cantonese corpses. During 1939-1943, the infection rate among in-patients of the Red Cross First Hospital in Shanghai was 0.7% (171/23797); and 90% (155/171) of the sufferers were Cantonese. During 1935-1944, the infection rate of in-patients at the same hospital was 0.72% (355/46517); and 90% of the 355 cases were Cantonese.<sup>144</sup>

During 1987-1989, the first national parasitic investigation took place at 120 locations of 32 counties in Jiangsu and found the total infection rate of CS was 0.5% (318/63699); most of the cases were found in Hsuzhou 徐州 and Huaiyin 淮陰 Cities with the infection rate of 1.9% and 0.5% respectively. (Hang Pan-yu et al., 1994) In 1999, the second investigation in 33 counties found the infection rate was 0.12% (26/21181) and these cases were mostly distributed in Suqian 宿遷 and Hsuzhou.<sup>145</sup>

During 1988-2006, investigations in Xinyi 新沂 City, located in the east of Hsuzhou, found the average infection rate was 1.21% (178/17422). In 2006, random surveys at five villages found the infection rate was 2.10% (56/2667). Moreover, the infection rate of cats was 73.33% (22/30) and that of dogs 60.00% (6/10). The reason of increase was because fish culture developed widely in Xinyi and excrements had

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<sup>139</sup> Faust and Barlow, 1924: 69-71.

<sup>140</sup> Fan Li-juan et al., 1997.

<sup>141</sup> Jefferys and Day, 1908; Day, 1910.

<sup>142</sup> Fischer, 1915.

<sup>143</sup> Komiya et al., 1935; Osaka, 1941.

<sup>144</sup> Ling and Taur 1949; Lan and Lin, 1949.

<sup>145</sup> Sun Fen-hua et al., 2000.

not been well treated before using as fertilizer and thus fish ponds were polluted.<sup>146</sup>

#### (4) Anhui

In Anhui, the earliest case of CS infection was found in Wuhu 蕪湖 in 1911 by Miyazaki Ichiro.<sup>147</sup> After 1986, data of six investigations are available. (1) In 1986, the SPA-ELISA method was applied to examine residents of three rural townships and elementary school pupils in Huiyuan 懷遠 County and found the total positive rate was 10.92% (114/1044); of which Qinji 岑集 had 11.05% (42/380), Suji 蘇集 11.02% (14/127), Weizhuang 魏庄 15.17% (44/290), and Weiyong 魏營 elementary school pupils 5.67% (14/247).<sup>148</sup> (2) In 1987, fecal examinations of students at three rural townships in Huiyuan County found the infection rate was 4.7% (276/5864).<sup>149</sup> (3) In 1986-1989, sample surveys at 102 locations in 24 counties found the average infection rate was 1.44% (784/54392); and the highest rate, 3.55% (644/18141), was found in the plain area of northern Anhui.<sup>150</sup> (4) By 1992, the ELISA method was applied to examine residents of a village in Mengcheng 蒙城 County and found the positive rate was 27.8% (218/785), and the infection rate by fecal examinations was 10.3% (81/785).<sup>151</sup> (5) From 1993, investigations among fishermen and farmers along the Huai River in Huainan 淮南 City found the infection rate was 42.3% (140/274), and there was a difference between male 51.4% (72/140) and female 32.8% (44/134). A random survey of 60 elementary school pupils found the infection rate was 15.0%.<sup>152</sup> (6) In 2002-2004, surveys at 27 locations in 10 counties found the infection rate was 0.72% (105/14541); this rate was 46.5% lower than that of 1992.<sup>153</sup> In northern Anhui, residents were accustomed to eat half-baked fish, but following the improvement of economic conditions more people could afford to enjoy raw fish at restaurants and thus the infection rate increased.<sup>154</sup> Moreover, around 2005, a survey among medical students found the total infection rate was 2.58% (17/659). There was a difference between the students coming from urban area 4.20% (10/238) and those from rural area 1.66% (7/421); the higher infection rate of urban students was due to their habits of eating raw fish and shrimp.<sup>155</sup>

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<sup>146</sup> So Ge-hua et al., 2007; Zhang Zhi-cai et al., 2007.

<sup>147</sup> Guo Jia et al., 2005.

<sup>148</sup> Hu Shou-feng et al., 1988.

<sup>149</sup> Zheng Shi-lian et al., 1988.

<sup>150</sup> Xu Fu-niu et al., 1992.

<sup>151</sup> Zhang Yao-bi, 1994.

<sup>152</sup> Zhu Yu-xia et al., 2001.

<sup>153</sup> Guo Jian-do et al., 2007.

<sup>154</sup> Guo Jia et al., 2005.

<sup>155</sup> Yang Qing-gui et al., 2006.

## (5) Jiangxi

In Jiangxi, there were 9 cases of Clonorchiasis reported in 1958.<sup>156</sup> After 1973, Jiujiang九江, Fuzhou撫州, and Yichun宜春 had also reported some cases. In 1980-1983, endemic areas were found in Yichun City and County, as well as Shanggao上高, Gaoan高安, Fengcheng豐城, Fengxin奉新 and Tonggu銅鼓 Counties. Surveys in Shanggao, Gaoan, and Yichun City found the infection rate was 4.5% (70/1558); and 62.5% of the sufferers were children.<sup>157</sup> In 1988-1989, random surveys of 52,042 persons in 23 counties found the total infection rate was 0.1%; and 43.5% of the sufferers were distributed in 10 counties with the highest rates found in Ruichang瑞昌 City (5-20%) in northern Jiangxi. The IHA method (indirect haemagglutination test) was applied to examine elementary school pupils in Ruichang and found the positive rate was 10.95% (5195/47438).<sup>158</sup> In 1994, surveys at three villages in Ruichang found the infection rate was 23.5% (122/520). It was also found that infection rates varied with habits of eating fish; those who liked to eat baked raw fish had 32.5% (108/332), those who liked to keep raw fish in mouth had 13.2% (5/38), and those who liked to eat dry raw fish had 11.4% (9/79).<sup>159</sup>

## (6) Hubei

In 1908, Booth reported that in Hankou the infection rate of *CS* was 2.16 % (3/139).<sup>160</sup> In 1921, Faust and Wassell conducted examinations of parasitic infection at the Church General Hospital in Wuchang and found the infection rate of all parasites was 76.8% (276/359), of which only one case was *CS*. This patient confessed that he often ate half-cooked dry fish. This report also said that dogs and cats in Middle China were widely infected with *CS*.<sup>161</sup> In 1933, M. N. Andrews reported that human infection rate of *CS* was 8% in Wu-Han area.<sup>162</sup>

In the 1970s, the autopsy performed for a child's corpse in Hanchuan漢川 found more than 10,000 *CS* in the body, and examinations of 1,848 residents of the county found the infection rate was 0.85%.<sup>163</sup> In May 1993, a case of Clonorchiasis appeared at the Public Health Station of Panqiao Village潘橋村, Yangxin陽新 County, and thus from June to November, the improved Kato-Katz method was applied to investigate at 20 locations and found the infection rate was 5.8% (398/6865) and there was a difference between male 7.3% (267/3641) and female 4.1%

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<sup>156</sup> Zhou Xian-min et al., 1994.

<sup>157</sup> Yi Ming-hua, 1983.

<sup>158</sup> Pan Bing-rong et al., 1994.

<sup>159</sup> Jiang Wei-sheng et al., 1995.

<sup>160</sup> Booth, 1909.

<sup>161</sup> Faust and Wassell, 1921.

<sup>162</sup> Osaka, 1941.

<sup>163</sup> Wu Zhi-xu et al., 1995.

(131/3215).<sup>164</sup> In July 1998, sample surveys at five villages in Icheng宜城 City found the infection rate was 2.4% (11/468). The locations investigated this time had many ditches and ponds with fishes and snails propagated thus provided suitable conditions for the infection of CS.<sup>165</sup> Moreover, from March 2003 to December 2004, an investigation at Xianning咸寧 City found the infection rate of male was 17.5% and that of female 11.6%. It was also found that sufferers were mostly youngsters from hilly area and they liked to eat half-baked small fish and shrimp.<sup>166</sup>

## **(7) Hunan**

In Hunan, several investigations during 1971-1990 were conducted in Yongxing永興, Wugang武岡, Shaoyang邵陽, Lianyuan漣源, and Guiyang桂陽, altogether the infection rate was 7.5% (3036/40569) and there was a difference between male 12.9% (105/814) and female 8.8% (75/857). Individually, the infection rates available were as follows: Yongxing had 27.4% (88/321) in 1971 and 27.5% (61/222) in 1990; Lianyuan had 5.8% (122/2108) in 1972; Guiyang had 29.6% (94/318) in 1976; Wugang had 2.1% (696/33828) in 1973-1981; Xiangtan湘潭 had 5.3% (23/434) in 1980 and 9.8% (26/266) in 1989; Qiyang祁陽 had 85.2% (1820/2136) in 1980-1984; Lixian澧縣 had 3.2% (83/627) in 1982; Shaoyang had 14.1% (13/92) in 1984; and Yuanjiang沅江 had 4.6% (10/217) in 1984. In general, these investigations found that residents in Hunan did not eat raw fish, except for the people in rural area of Qiyang and children there liked to catch fish and play by keeping fish in the mouth.<sup>167</sup>

During 1996-1999, examinations of 342 residents and elementary school pupils along the west bank of Xiang湘 River at Yuelu岳麓 district in Changsha長沙 did not discover any infection.<sup>168</sup> In 2002, surveys at three villages of three townships in Yongxing County found the total infection rate was 3.6% (55/1546). In 2005, surveys at two villages of Xiangyindu Town湘陰渡鎮 found the infection rate was 3.1% (14/446). These rates were much lower than that in 1990. The reduction of infection rate was because residents of Yongxing had changed their habit and a new method of fish culture was adopted to prevent pollution of water and thus mitigated the infections of intermediate hosts.<sup>169</sup>

## **(8) Sichuan**

In 1943, it was reported that in Chengdu成都 cats were infected seriously with

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<sup>164</sup> Chen Si-li et al., 1996.

<sup>165</sup> Xu Zheng-min et al., 2002.

<sup>166</sup> Chen Si-li et al., 2006.

<sup>167</sup> Wang Jun-hua et al., 1994.

<sup>168</sup> Liu Nian-meng et al., 2000.

<sup>169</sup> Liao Guo-le et al., 2006.



CS but dogs were not.<sup>170</sup> In 1947, it was found that the infection rate among residents in Chengdu was 0.7% (9/1176); and of the nine sufferers, three came from Guangdong.<sup>171</sup>

After 1988, investigations revealed that Chongqing重慶 area had the highest infection rate of CS in Sichuan. As mentioned above, the infection rate of Chongqing ranked the fifth in the second national investigation in 2001-2004. The total infection rate of Chongqing was 4.1% (982/23738) during 1988-2002 and individual rates within its jurisdiction were as follows: Tongnan潼南 15.9% (289/1815), Dianjiang墊江 10.0% (413/4112), Changshou長壽 5.1% (86/1686), Shapingba沙坪壩 4.9% (98/2006), Hechuan合川 4.1% (47/1134), Ronchang榮昌 3.0% (27/900), Tongliang銅梁 1.2% (5/422), Jiangjin江津 0.8% (7/869), Yongchuan永川 0.6% (2/333), Bishan璧山 0.5% (8/1515), and no infection was found in Wanzhou萬州, Liangping梁平, Yunyang雲陽, Kaixian開縣, Wushan巫山, Fuling涪陵, and Fengdu豐都.<sup>172</sup>

Within the jurisdiction of Chongqing, the highest infection rate was found in Tongnan, where the Qiong琼 and the Fu涪 Rivers run through with an abundant resource of fish at the Qiong River Basin. During 1978-2002, surveys at three villages of the upper, middle and lower reaches along the Qiong River found the total infection rate was 18.3% (386/2105). During 1978-1980, consecutive surveys at the three villages found the infection rate at the upper village was 30.5% (231/758), the middle village 16.3% (111/681), and the lower village 6.6% (44/666). In 1986-1989, surveys at Lingjiang Village臨江村 found the infection rate in 1986 before curing was 24.2% (342/1414), and after curing, it was 6.7% (84/1254) in 1987 and 0.2% (3/1231) in 1989. In October 2002, the three villages at upper, middle and lower reaches were investigated again and found the total infection rate was 2.8% (42/1508) and individual rates were 4.4% (22/502), 3.6% (18/506) and 0.4% (2/500) respectively. The decreasing rates reflected the effect of curing. (Zhou Zi-lun et al., 2003) In 2004-2006, a survey at Changshou Village長壽村, located at the upper Qiong River, found the infection rate was 11.4% (22/197) in 2004, 4.3% (19/447) in 2005, and 3.3% (12/367) in 2006, and the total rate was 5.2% (53/1011), which was much lower than the 24.2% (342/1414) in 1986. The reduction also indicated the effect of curing.<sup>173</sup>

The next highest infection rate was found in Dianjiang where measures of control were adopted at Jixiang Village吉祥村 in 1982-1986 and the infection rate decreased from 15.2% to 0.9%. In September 1995, both fecal examinations and Dot-ELISA serum tests were applied to examine residents and elementary school

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<sup>170</sup> Kuo and Kiang, 1943.

<sup>171</sup> Hsu Kuo-Chin, 1947.

<sup>172</sup> Jiang Shi-guo et al., 2003.

<sup>173</sup> Jiang Shi-guo et al., 2007.

pupils at this village; the serum tests found the positive rate was 6.2% (14/226) for residents and 3.8% (17/445) for pupils; the fecal examinations found the infection rates were 1.3% (3/228) and 1.0% (4/419) respectively. These results showed little difference from those found in 1986.<sup>174</sup>

In 1987-1991, measures of control were adopted at Zhijiadian Village 支家店村 in Zhongjiang County. As a result, the infection rate was reduced from 20.9% (230/1103) in 1987 to 4.5% (51/1139) in 1991 and further to 0.3% (2/628) in 1995. The experience of Zhijiadian Village demonstrated that proper measures and health education for the people within a limited area could bring this food borne infection under efficient control. During 1990-1992, surveys at elementary and middle schools in Zhongjiang, Anyue 安岳, and Lezhi 樂至 Counties found the infection rates as follows: in Zhongjiang, the rate of middle school students was 12.3% (70/570) and that of elementary school pupils 3.6% (21/584); in Anyue, the rate of middle school students was 9.4% (13/139) and the pupils had no infection; in Lezhi, middle school students had 9.9% (14/142) and elementary school pupils 2.4% (3/124). These results showed that middle school students had a higher infection rate. Although economic and public health conditions had been improved in rural area, youngsters still lack of awareness to protection themselves and still like to eat half-baked small fish when they play along streams.<sup>175</sup>

In 1978-1990, investigations at 28 locations in Chengdu found the infection rate was 6.0% (894/14865). Investigations at four villages in Pengxi 蓬溪 County found the infection rate was 2.7% (71/2606). In 1989, investigations at five locations in Jiajiang 夾江 County found two sufferers at Ganlu Rural Township 甘露鄉 and the infection rate was 0.07% (2/2703). Because the two sufferers had never traveled outside of the village, this finding proved that Clonorchiasis existed in this village for the first time.<sup>176</sup>

In addition to provinces discussed above, a report in 2007 concerning the situation of parasitic infection in southeastern Guizhou mentioned CS but the infection rate was not clear.<sup>177</sup>

### 3.5 North China

In the 1920s, Faust reported that cats and dogs in North China were highly infected by CS. For instance, in Peking 37% of cats and 25% of dogs were infected, but there was no human infection because people tended to eat fully cooked fish.<sup>178</sup>

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<sup>174</sup> Li Juan-you et al., 1998.

<sup>175</sup> Zeng Ming-an et al., 1995.

<sup>176</sup> Lan Xiao-hui et al., 2002; Wang Cheng-ke, 1994; Zheng De-fu et al., 1994.

<sup>177</sup> Wu Nian-biao et al., 2007.

<sup>178</sup> Faust, 1921; 1925a; 1925b.

The infection rates of CS in North China in 1960-2004 are illustrated in Map 8.



Map 8: The Infection Rate of Clonorchiasis in North China, 1960-2004

### (1) Shandong

In Shandong, it was found in 1962 that the infection of CS was distributed in 99 counties (cities, districts) located at low-lying area in the province's middle, southern, and coastal regions, and the average infection rate was 2.3%, but the highest rate, 44.4%, was found among elementary school pupils.<sup>179</sup> Consecutive investigations at 107 of the 139 counties (cities, districts) found the infection rates of residents at rural area varied from 1% to 30% and at some schools it was more than 40%. After many years of investigation and control the situation became stabilized in 1987. Available data of the infection rates are as follows: In 1960-1970, the infection rate of 96 counties was 1.5% (62646/4166180); in 1980, the rate of 75 counties was 1.2% (7855/683936); and in 1990, the rate of 55 counties was 0.3% (158/53474). There was no significant difference between the male and female rates. Of the 158 cases found in 1990, there were 97 cases (61.4%) distributed in the southwest (Heze荷澤, Jining濟寧, Tsaozhuang棗莊, Linyi臨沂), 20 cases (12.7%) in the north (Dezhou德州, Binzhou濱洲, Dongying東營), and 12 cases (7.6%) in the east (Qingdao青島, Yantai

<sup>179</sup> Zhu Yu-guang, 1983.

煙台). These results were identical to the fact that there were more ponds containing water all year round in these areas. It was reported that in recent years, many rivers in Shandong were polluted by industrial waste water, but a certain amount of intermediate hosts of CS still survived in some ponds and rivers. In 1990, investigations in 48 counties each with samples from three villages found the total infection rate was 0.33% (151/46323); and there was no significant difference between male and female.<sup>180</sup>

In Linyi area, investigations during 1989-1991 at 13,511 villages found that 5,399 villages of these villages had ponds containing water all year round; residents of 519 villages received examinations and the infection rate was 0.7% (550/79938). There were 21 villages where the infection rate was more than 3% and consequent investigations at these villages found the infection rates ranged from 0.02% to 6.9%, and the total infection rate was 2.2% (423/19209). After the investigation, there was followed-up curing for one month and then 19 villages were investigated again; as a result the total infection rate was reduced to 0.2% (5/2496).<sup>181</sup>

In November 1991, sample surveys in Junan莒南 County found the infection rate at Gaoyu Village高榆村 was 0.56% (1/179) and zero (0/96) at Wanbianshan Village萬扁山村. Surveys in 1992 at four villages found the infection rates as follows: Wanbianshan 0.68% (1/147), Gaoyu zero (0/171), Tsuitang崔堂 2.13% (4/188), and Liuhang柳行 0.99% (2/210). In 1993, it was found that both Wanbianshan (0/120) and Gaoyu (0/119) had no infection, while Tsuitang had 1.17% (2/171) and Liuhang 1.68% (3/178). No increasing trend was observable because public health conditions had been improved and the people had changed their daily habits.<sup>182</sup>

In Juye巨野 County, consecutive investigations at five villages during 1987-1994 found the infection rate was 5% (150/3000).<sup>183</sup>

In Jinxiang金鄉 County, investigations in 1979-1980 found the infection rate was 2.2% (729/33721). In 1987-1988, investigations and measures of control were adopted at villages where the infection rate was above 1% and the ponds kept water all year round. The result of investigations showed that the infection rate was 1.2% (359/29640). In 1993-1995, sample surveys at villages with high, medium and low infection rates found that the total infection rate was 0.09% (7/8136).<sup>184</sup> It was notable that the infection rate of Jinxiang was 1.02% (4835/478118) in 1989 and a comprehensive program of curing was carried out by given medicine to all sufferers. In 2000, the effect of curing was examined at 183 villages and found that the infection

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<sup>180</sup> Wan Gong-qun et al., 2000; 2002.

<sup>181</sup> Li Deng-jun et al., 1994b; 2007.

<sup>182</sup> Li Deng-jun et al., 1994a; 1996.

<sup>183</sup> Jiang Yu-lan et al., 1997.

<sup>184</sup> Jin Yu-zhu et al., 1998.

rate was reduced to 0.63% (135/21364). Compared with the infection rate of 1.45% in 1998, the reduction was significant. In 2002, however, 49 new cases were found at places where high infection rates were observed before.<sup>185</sup>

In Heze City, during 1977-1990, residents above three years old at villages located closely to the Zhuzhaoxin 洙趙新 River received examinations and the infection rate was 2.6% (139/5446). It was pointed out that the infection of CS prevailed in this area because of the following reasons: (1) The fish culture was developing and feces of chickens, ducks, and pigs were utilized to feed fish and shrimp; (2) The people liked to keep small fish in mouth when fishing and to eat raw or half-baked fish; (3) CS produced a large amount of eggs and had enduring adaptability, while snails, the first intermediate hosts, existed widely in the water.<sup>186</sup> In November 1991, another investigation at three villages found that the infection rate was 0.19% (2/1047).<sup>187</sup>

In Sishui 泗水 County, the CS infection was first confirmed in 1962. In 1963, surveys at four villages along the Si 泗 River found the infection rate was 1.55%. In 1980, infection rate of residents at Sishui Town was 0.96%. In April 1996, surveys at three villages along the river found the total infection rate was 0.18% (2/1128); the two sufferers were females living at Houzhai Village 后寨村 where the infection rate was 0.37% (2/546). It was reported that these two sufferers had experiences of eating raw fish and moved into the village respectively from towns of Miaoguan 苗館 and Xingcun 星村 where no investigation had been conducted. Moreover, in 1980, the infection rate of Dabao Village 大鮑村 was 0.28% and that of Hsujialou Village 徐家樓村 0.57%. Re-investigations at the two villages in 1996 found no infection, indicating the effect of curing.<sup>188</sup>

In Tsaozhuang City, investigation at Yuelou Village 岳樓村 in 1975 found the infection rate was 7.0% (48/687) with no difference between male and female. In 2000, retrospective investigation found that of the 48 cases, four had died and 12 moved out, and re-examinations of the other 32 cases did not found any egg. At the same time, samples of 310 persons (162 male and 148 female) showed no infection, indicating the effect of curing. It was pointed out that previously, environment and health conditions were rather poor at Yuelou Village where there were lots of ponds and excrements from latrines and waste water of the village all flowed into ponds. All sufferers had the habit of eating fish raw or half-baked. After investigations, certain measures were taken to improve the living conditions and health education of the residents. In 2000, the village had become an industrial district with the environment

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<sup>185</sup> Chen Ji-feng et al., 2002.

<sup>186</sup> Sun Yuan-chao et al., 1999.

<sup>187</sup> Wang Su-zhen et al., 2002.

<sup>188</sup> Tao Shi-kun, 2003.

and public health largely improved and the residents had changed their old habit.<sup>189</sup>

In 1994, examinations for students of elementary and middle schools at Taierzhuang 台兒莊 district in Tsaozhuang found the average infection rate was 7.2% and the highest rate was 23.5%. During 1985-1995, investigations and measures of control were widely conducted for five times and the infection rate was reduced to 1%. In 2000, sample surveys found the infection rate was 0.3% (5/1550).<sup>190</sup> In Boxing 博興 County, surveys at Dongjia Village 董家村 in 1992 found the infection rate was 4.8% (104/2164) for residents and 6.6% (28/426) for students.<sup>191</sup>

A review article in 2007 contended that the infection of *CS* in Shandong had been brought under control because of the following reasons: (1) A combination of investigation, control, and health education had produced significant effects; (2) The people had changed their daily habits along with the improvement of economic conditions and popularity of health knowledge; (3) As the climate in Shandong continued to be dry, many ponds had dry up and wild fishes and snails lost the environment for propagation. It was suggested that the experience of control and health education in Shandong could provide a good example for other provinces.<sup>192</sup>

## (2) Hebei

In Hebei, there were surveys at Tangshan 唐山 and Funing 撫寧 in 1980 and found the infection rates of *CS* among residents were respectively 3.6% (3/83) and 4.9% (46/936), and that of elementary school pupils was 1.5% (4/266).<sup>193</sup> Available data are mostly related to Tianjin. From September 2003 to May 2004, sample surveys at 30 locations of Tianjin area found the infection rate was 0.16% (19/12000); among the locations investigated, only Jixian 藺縣 had 0.51% and Wuqing 武清 had 0.06% while others had no infection. The higher infection rate at Jixian was possibly due to the habit of eating raw fish.<sup>194</sup>

## 4. Concluding Remark

The infection of *Clonorchis sinensis* forms a cycle among the parasite, the intermediate hosts, and the final hosts. Rivers, lakes and ponds provide suitable environment for intermediate hosts to propagate but it is human actions that make this cycle to run over and over again. Human practices in fish culture implied an idea of utilizing waste but the danger of parasitic infection was ignored. Moreover, the habit

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<sup>189</sup> Li Ping-luan et al., 2001; Fu Mei-rong, 2003.

<sup>190</sup> Xue Ying-hui et al., 2001.

<sup>191</sup> Li Guo-qian et al., 1998.

<sup>192</sup> Li Deng-jun et al., 2007.

<sup>193</sup> Huang su-fang et al., 1983; Gao Yong, 1983.

<sup>194</sup> Zhu Chuan-fang et al., 2006.

of eating raw or half-cooked fish induced the infection of CS. Besides the infection rates in each area presented above, there are also substantial studies on intermediate hosts and other animal hosts but they should be discussed in another paper.

It should be noted that as early as 1925 Faust pointed out the necessity of educating Cantonese about the harmfulness of eating raw fish in order to eliminate the infection of CS in the next generation.<sup>195</sup> In 1937, Hsü and Chow also emphasized that it was urgent to educate Cantonese and if they could give up eating raw fish, the infection of CS would disappear naturally.<sup>196</sup>

Since the 1990s, the infection of CS in Taiwan and Mainland China was gradually under control with medical treatment. However, the opening of trade and traveling between Taiwan and the Mainland as well as entrance of foreign brides and workers into Taiwan also brought certain danger of new infection. Particularly, the appearance of Thai liver fluke should not be overlooked. In Mainland China, in many places measures of control had been adopted and the infection rate had been reduced to some extent, however, the infection rate was still increasing in many other places as economic conditions were gradually improved since the late 20th century and there were more people who could afford and had acquired the habit of consuming raw fish. Moreover, the increasing opportunities of traveling to endemic area also help in spreading the infection. Thus, in addition to medical care, whether education alone can be effective in preventing the infection of CS among the people and to break the cycle of transmission is a problem required serious study.<sup>197</sup>

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<sup>195</sup> Faust, 1925a: 402.

<sup>196</sup> Hsü and Chow, 1937: 351.

<sup>197</sup> E.g., Cao Zhi-guo, 2007.

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