

ANNUAL ECONOMIC LOSS CAUSED BY *TAENIA SAGINATA ASIATICA* TAENIASIS IN THREE ENDEMIC AREAS OF EAST ASIA

PC Fan

Department of Parasitology, School of Medicine, National Yangming University, Taipei, Taiwan

Abstract. The *Taenia saginata*-like tapeworm in East Asia has been designed as a separate subspecies of *T. saginata*. It was named as *T. saginata asiatica* and the classical *T. saginata* as *T. saginata saginata*. In the course of conducting experimental infections and morphological studies, a large number of adult worms of *T. saginata asiatica* was collected. It is possible to estimate the annual economic loss caused by this infection, since the worm load and the weight of worm harbored by each infected person were determined from the collection. In the mountainous areas of Taiwan, the infection rate of *T. saginata asiatica* taeniasis was 11.0%, the worm load was 1.6 worms/case, and the average weight of an adult worm was 20.5 g. The annual economic loss was estimated to be US\$ 11,327,423. On Cheju Island of Korea, the infection rate was 6.0%, the worm load was 2 worms/case, and the average weight of an adult worm was 19.3 g. The annual economic loss was estimated to be US\$ 13,641,021. On Samosir Island of Indonesia, the infection rate was 21%, the worm load was 1.8 worms/case, and the average weight of an adult worm was 22 g. The annual economic loss was estimated to be US\$ 2,425,500. These figures indicate that taeniasis is not only a significant public health problem but also an important economic problem in East Asia.

INTRODUCTION

Taeniasis is an important food-borne zoonotic infection in the countries of East Asia. According to Fan (1983), 27,000 aborigines in the mountainous areas of Taiwan acquired the infection. An infection rate of 7% was found among inhabitants in two villages on Cheju Island of Korea (Soh *et al.*, 1988a). At Ambartia Village on Samosir Island in Lake Toba, North Sumatra, Indonesia, an infection rate of 21% was determined (Kosmen *et al.*, 1988).

Although the main causative agent of taeniasis in East Asia was believed to be *Taenia saginata*, this *T. saginata*-like tapeworm does not follow the usual

epidemiological pattern of *T. saginata*. People in this part of the world often eat meat and viscera of pigs and *Cysticercus cellulose* is frequently found. However, *T. saginata* rather than *T. solium* is the dominant species (Cho *et al.*, 1967; Huang, 1967; Arambulo *et al.*, 1976; Kosin *et al.*, 1972; Kim, 1985). This paradoxical phenomenon leads to the questions regarding the intermediate host (Huang, 1967; Cho *et al.*, 1967; Arambulo *et al.*, 1976). In order to clarify the taxonomic status of the Asian *Taenia*, we conducted a series of experimental infections (Fan *et al.*, 1987, 1989a, b, 1992a, b). The results of our studies and molecular studies (Zarlenga, 1991; Zarlenga *et al.*, 1991; Bowles and McManus, 1994) lead us to the conclusion that the Asian *Taenia* is a separate subspecies from classical *T. saginata*. Asian *Taenia* is now designated as *T. saginata asiatica* and classical *T. saginata* as *T. saginata saginata* (Fan *et al.*, 1995).

In the course of our morphological studies and experimental infections, we have administered atabrine

Correspondence : Dr PC Fan, Department of Parasitology, School of Medicine, National Yangming University, Taipei, Taiwan, Republic of China.

to the infected inhabitants in the mountainous areas of Taiwan, Cheju Island of Korea, and Samosir Island of Indonesia and collected a large number of complete tapeworms. These collections make us possible to determine the worm load and weight of *T. saginata asiatica* in each of the infected person. These figures can be used to estimate the annual economic loss cause by this infection. In this paper, we present an analysis of the annual economic loss cause by the infection of *T. saginata asiatica* in the mountainous areas of Taiwan, Cheju Island of Korea, and Samosir Island of Indonesia.

ANNUAL ECONOMIC LOSS DUE TO TAENIASIS IN TAIWAN

There were 360,073 aborigines at the mountainous areas of Taiwan (Chen, 1995, personal communication) with an average infection rate of 11.0% for taeniasis and they had a worm load of 1.6 worms/case (Fan, 1992). Hence, a total number of 39,608 aborigines were estimated to harbor 63,373 worms. Since the average weight of a *Taenia* worm was 20.5 g, the aborigines harbored 1,299 kg of worms which was equivalent to the body weight of 32 aborigines (average body weight/aborigine = 40 kg). Therefore, the annual living expense (food only) by the 32 aboriginal subjects was US\$ 43,104 (living expense/aborigine/year = US\$ 1,347 (Tsai, 1995, personal communication).

In addition, there was an average annual loss of seven working days for each aboriginal case. Hence, the total loss of working days was 277,256. The total loss of wages was US\$ 10,258,472 (since the average wage of a working day = US\$ 37.0 (Tsai, 1995, personal communication). The total annual loss of medical care due to taeniasis was estimated to be US\$ 1,025,847 (average cost of medical care/case = US\$ 25.9). Therefore, this infection caused an overall economic loss of US\$ 11,327,423 per year in the mountainous areas of Taiwan (Table 1).

ANNUAL ECONOMIC LOSS DUE TO TAENIASIS ON CHEJU ISLAND OF KOREA

There were 511,019 inhabitants on Cheju Island of Korea (Kim, 1995, personal communication) with

an average infection rate 6.0% for taeniasis and they had a worm load of 2 worms/case (Soh *et al.*, 1988a). Hence, a total number of 30,611 inhabitants were estimated to harbor 61,322 worms. Since the average weight of a *Taenia* worm was 19.3 g, the inhabitants harbored 1,184 kg of worms which was equivalent to the body weight of 30 inhabitants (average body weight/inhabitant = 40 kg). Therefore, the annual living expense (food only) by the 30 subjects was US\$ 119,520 (living expense/inhabitant/year = US\$ 3,984 (Kim, 1995, personal communication).

In addition, there was an average annual loss of seven working days for each case. Hence, the total loss of working days was 214,627. The total loss of wages was US\$ 8,585,080 (since the average wage of a working day = US\$ 40 (Kim, 1995, personal communication). The total annual loss of medical care due to taeniasis was estimated to be US\$ 4,936,421 (average cost of medical care/case = US\$ 161). Therefore, this infection caused an overall economic loss of US\$ 13,641,021 per year on Cheju Island of Korea (Table 1).

ANNUAL ECONOMIC LOSS DUE TO TAENIASIS ON SAMOSIR ISLAND OF INDONESIA

There were 600,000 inhabitants on Samosir Island of Indonesia (Kosin, 1995, personal communication) with an average infection rate 21% for taeniasis and they had a worm load of 1.8 worms/case (Fan *et al.*, 1989b) Hence, a total number of 126,000 inhabitants were estimated to harbor 266,800 worms. Since the average weight of a *Taenia* worm was 22 g, the inhabitants harbored 5,870 kg of worms which was equivalent to the body weight of 147 inhabitants (average body weight/aborigine = 40 kg). Therefore, the annual living expense (food only) by the 147 subjects was US\$ 44,100 (living expense/inhabitant/month = US\$ 300 (Kosin, 1995, personal communication).

In addition, there was an annual loss of seven working days for each case. Hence, the total loss of working days was 882,000. The total loss of wages was US\$ 1,764,000 (since the average wage of a work-

ing day = US\$ 2). The total annual loss of medical care due to taeniasis was estimated to be US\$ 617,400 (average cost of medical care/case = US\$ 4.9).

Therefore, this infection caused an overall economic loss of US\$ 2,425,500 per year on Samosir Island of Indonesia (Table 1).

Table 1

Estimation on annual economic loss of *Taenia saginata asiatica* taeniasis in three endemic areas, East Asia.

	Mountainous areas, Taiwan ROC	Cheju Island, Korea	Samosir Island, Indonesia
A. Population	360,073 ^a	511,019 ^b	600,000 ^c
B. Overall infection rate	11 ^d	6 ^f	21 ^g
C. Total number of case (A×B)	39,608	30,661	126,000
D. Average no. of worms/case	1.6 ^d	2 ^f	1.8 ^g
E. Total no. of worms (C×D)	63,373	61,322	266,800
F. Average weight/worm (g)	20.5	19.3	22
G. Total weight of worms (kg) (E×F)	1,299	1,184	5,870
H. Average body weight/case	40	40	40
I. Total no. of person equal to the total weight of worms (G/H)	32	30	147
J. Average living expenses (food only)/person/year (US\$)	1,347 ^e	3,984 ^b	300 ^c
K. Total living expenses (food only)/person/year (US\$) (I×J)	43,104	119,520	44,100
L. Average rest of period (days)/case/year	7	7	7
M. Total loss of working days (C×L)	277,256	214,627	882,000
N. Average wage of a working day (US\$)	37.0 ^e	40 ^b	2 ^c
O. Total loss of wages (M×N) (US\$)	10,258,427	8,585,080	1,764,000
P. Average cost of medical care/case (US\$)	25.9 ^e	161 ^b	4.9 ^c
Q. Total loss of medical care (C×P) (US\$)	1,025,847	4,936,421	617,400
R. Total annual loss (K+O+Q) (US\$)	11,327,423	13,641,021	2,425,500

- a. Chen CY, 1995 (Personal communication)
 b. Kim SH, 1995 (Personal communication)
 c. Kosin E, 1995 (Personal communication)
 d. Fan PC, 1992
 e. Tsai SH, 1995 (Personal communication)
 f. Soh CT *et al*, 1988b.
 g. Fan PC *et al*, 1990d.

DISCUSSION

Since 1981, we have used atabrine, mebendazole, albendazole, niclosamide and praziquantel to treat thousands of aboriginal patients with taeniasis in the mountainous areas of Taiwan (Liu *et al*, 1981; Fan *et al*, 1986, 1990; Chung *et al*, 1991). In addition, chemotherapeutic trials have also been carried out on

Cheju Island, Korea (Soh *et al*, 1988a) and Samosir Island, Northern Sumatra, Indonesia (Kosman *et al*, 1988). The worm loads were found to be 1.6 worms/case, 2 worms/case, and 1.8 worms/case in these endemic areas, respectively. One third (33%) of the Taiwan aboriginal patients were found to have multiple infection (Fan *et al*, 1988). Moreover, Chung *et al* (1978) found a family with all 10 member

infected in Jenai District, Nantou Country, Taiwan. Seventy-two worms was recovered and one member expelled 24 worms. This is contrary to the generally belief that infection with *T. saginata* usually consists of single worm. Therefore, taeniasis of *T. saginata asiatica* is a multiple infection.

Cysticercosis is a significant food safety problem. Abdussalam (1975) estimated that bovine and porcine cysticercosis caused an annual loss of US 428,000,000 in South America, where the overall infection rate of this infection was 2.0%. In Mexico, porcine cysticercosis (overall infection rate 1.6%) caused a loss of US\$ 68,000,000/year (Acevedo-Hernandez, 1982). Mann (1983) estimated that there was an annual loss of US\$ 1,800,000,000 due to bovine cysticercosis (overall infection rate = 7%). In Kenya and Botswana, bovine cysticercosis caused respectively annual losses of US\$ 4,000,000 and US\$ 2,000,000 (Grindle, 1978).

In addition to causing economic losses in food production (cysticercosis in domestic animals), tapeworms also give rise to medical costs and wage losses (taeniasis and cysticercosis in human). Robert (1985) estimated that there is an annual loss of US\$ 100,000 (US\$ 111/patient) due to the treatment of taeniasis in the United States. In Mexico, neurocysticercosis causes annual wage losses of US\$ 345,000,000 and medical costs of US\$ 17,000,000 (Velasco-Suarez *et al*, 1982). In the present study, we determined that taeniasis causes an annual economic loss of US\$ 11,140,559 in the mountainous areas of Taiwan, US\$ 13,641,021 on Cheju Island of Korea, and US\$ 2,425,500 on Samosir Island, Indonesia. These figures suggest that taeniasis is not only a significant public health problem but also an important economic problem in East Asia.

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