

Natural infections of Asian *Taenia saginata* metacestodes in the livers of Korean domestic pigs*

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Abstract: The *Taenia* species in East Asia, hitherto identified as *Taenia saginata*, has been recognized as differing from the classical descriptions of life cycles and was recently named *Taenia saginata taiwanensis* (tentatively until 1992). Major differences between *T. saginata* and the newly recognized Asian *T. saginata* are their intermediate hosts and the infected tissues. Asian *T. saginata* metacestodes are found in the livers of pigs rather than in the muscles of cattle. In this study, we observed the natural infection status of Asian *T. saginata* metacestodes in the livers of 25,358 pigs at an abattoir in Cheongju City, Korea, from 1989 to 1990. Total 256 livers (1.01%) were infected with 1~96 (mean 2.5 per capita) metacestodes. Most of the metacestodes, however, were either calcified (87.1%) or highly degenerated (12.9%). Living metacestodes were found in only 0.01% (3/25,358) of the examined livers. And these were distributed randomly in each lobe of the livers. The liver of pigs in Korea was confirmed as an organ hosting the Asian *T. saginata* metacestode. But its epidemiological significance as a source of human infections should be properly evaluated because of the rarity of the living metacestodes.

Key words: Asian *Taenia saginata*, metacestodes, natural infection status, livers, Korean domestic pigs

INTRODUCTION

Of the tapeworms infecting people in Korea, *Taenia solium* and *Taenia saginata* have long been recognized. Epidemiological studies have shown different degrees of endemicity in different areas. It has also been recognized that *T. saginata* is a dominant species over *T. solium* in ratios that range from 9:1 to 7:3 when the worms were identified morphologically after expulsion by chemotherapy (Kang *et al.*, 1965a;

Lee *et al.*, 1966; Cho *et al.*, 1967). This ratio of *T. saginata* to *T. solium* among the population of Korea cannot be easily explained according to conventional understanding that human infection with *T. saginata* comes through infected beef and *T. solium* through infected pork. Many surveys on the eating habits of Korean people showed that they consumed raw pork and beef in almost equal frequency (Park and Chyu, 1963; Kang *et al.*, 1965b; Cho *et al.*, 1967; Kim, 1982). The enigma had been highlighted most apparently by Hong *et al.* (1983) in their study on taeniasis in Sorok Island, southern Korea. Despite the absence of cattle on the island, all the infected inhabitants had only *T.*

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saginata (-like cestode).

In relation with these enigmatic problems, an interesting experiment was done by Chao *et al.* (1979) suggesting the difference between the *Taenia* species in Taiwan and the species in America. The organ of cattle infected by Taiwan *Taenia* was usually the liver but not the muscle, the organ ordinarily infected by *T. saginata* metacestodes. Liu *et al.* (1981) suggested the possibility of the Taiwan tapeworm as a new species.

Fan *et al.* (1986 & 1987) and Chung *et al.* (1987) reported goats, cattle, Lanyu pigs (native pigs in Lanyu Island of Taiwan) and wild boars as experimental or possible natural intermediate hosts. Only a few reports on the natural infection status of Asian *T. saginata* metacestodes are available. In Taiwan, a total of 14 out of 72 examined wild boars and Lanyu pigs were infected with Asian *T. saginata* metacestodes according to Fan *et al.* (1987) and Chung *et al.* (1987 & 1988).

Recent studies of tapeworms and metacestodes show that this same species may be present in such Asian countries as Taiwan, Korea, Thailand and Indonesia (Fan *et al.*, 1988 & 1990; Soh *et al.*, 1988; Kosman *et al.*, 1990).

Now this tapeworm is tentatively named *Taenia saginata taiwanensis* until 1992 according to an agreement made at the 33rd SEAMEO-TROPMED (South-east Asian Ministries of Education Organization Regional Tropical Medicine and Public Health) Regional Seminar on emerging problems in food-borne zoonosis (Cross and Murrell, 1991).

In this study, we surveyed the natural infection status of Asian *T. saginata* metacestodes in domestic pigs in an attempt to find the possible source of human infection with this species.

MATERIALS AND METHODS

From September 1989 to March 1991, the livers of 25,358 pigs were inspected intermittently at an abattoir in Cheongju City, Chungbuk Province, Korea. These pigs were collected from farm

houses in Cheongju City or Cheongwon Gun, with a small minority coming from Kyunggi Province. All were six month old cross-bred pigs of Yorkshire, Landrace, Duroc or Hampshire strains.

All surfaces of each pig liver were thoroughly inspected. When one or more white spots were detected on the surface, the livers were sliced in 2~3 mm thickness and observed by the naked eyes. Lesion scoring was done in each lobe of the liver. All spots were removed from the liver tissue and observed under a dissecting microscope between two slide glasses. The degree of calcification and worm degeneration was recorded. The viability of least degenerated metacestodes was determined by motility in 37°C physiologic saline.

RESULTS

Asian *Taenia saginata* metacestodes were observed on the liver surface as well as in the parenchyme (Fig. 1 & 2). They were surrounded by yellowish or milky white host tissue capsules and the diameter was in the range of 1~16 mm (Fig. 2). When metacestodes were alive, host tissue capsules were transparent and measured 3.20 mm in a range of 3.1~3.3 mm ($n=3$, S.D. 0.08). Host tissue capsules with degenerated metacestodes measured 4.98 mm in a range of 2.0~9.5 mm ($n=24$, S.D. 2.03) and those with calcified metacestodes measured 3.67 mm in a range of 1.0~16.0 mm ($n=387$, S.D. 2.55).

Host tissue capsules with living metacestodes contained transparent fluid surrounding the bladder worm. The capsule with degenerated metacestodes contained pus cells or mucopurulent fluid in the space between the thick yellowish host tissue capsule and the non-motile bladder worm (Fig. 3). Calcified capsules contained friable calcified bladder worms without fluid in thick and milky white host tissue capsules (Fig. 4).

Total 81 (46.0%) of 177 collected cysts were found on the surface while 96 (54.0%) were found in the parenchyme. By location, 14.7%

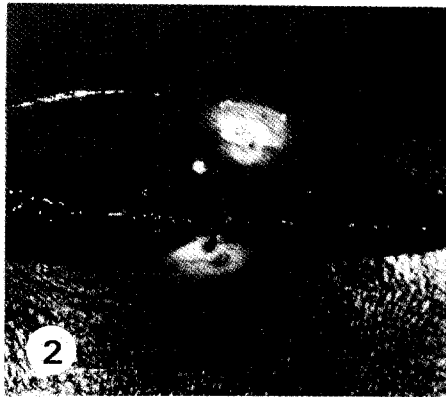
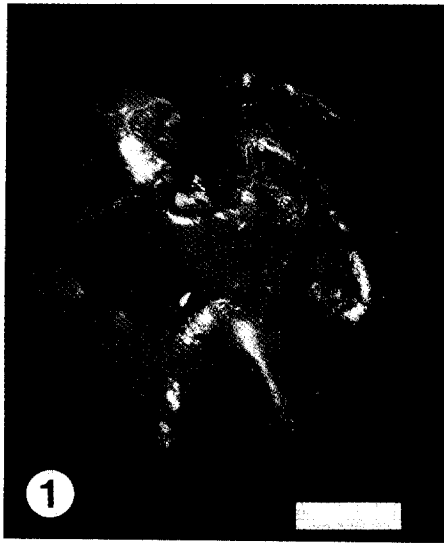


Fig. 1. Liver of a domestic pig naturally infected with many Asian *Taenia saginata* metacystodes on the dorsal surface.
Fig. 2. A metacystode exposed from the host tissue capsule on the cut surface of liver parenchyme.
Fig. 3. A degenerated metacystode with surrounding pus ($\times 20$).

were found in the right lateral lobe, 29.9% in the right medial lobe, 28.2% in the left medial lobe, and 27.1% in the left lateral lobe.

Of the 25,358 livers examined, Asian *T. saginata* metacystode was found in 256 (1.01%) pigs (Table 1). Of these 256 cysts, 223 were calcified, 30 were degenerated, and 3 had capsules with living metacystodes (Fig. 5). The mean number of cysts was 2.51 per pig (1~96). Most pigs harbored less than 5 cysts.

Scolecex of metacystodes had four suckers measuring 0.23~0.30 \times 0.19~0.22 mm of diameter ($n=8$) (Fig. 6). The width of the lower neck was 0.60~0.87 mm ($n=3$) and the maximum diameter of the scolex measured 0.83~1.4 mm ($n=3$). Eight of 47 metacystodes had rudimentary hooklets. Most of them ranged 2.5~10.0 μ m in length. Counting hooklets was impossible in most metacystodes but in one we counted 37 hooklets.

Table 1. Natural infection status of Asian *T. saginata* metacystodes in the livers of 25,358 pigs slaughtered at an abattoir in Cheongju, Korea

Status of cysticerci	No.(%) of pigs positive	Numbers of cysticerci		
		Collected	Mean	Range
Alive	3(0.01)	8	2.67	1~5
Dead	253(1.00)	635	2.51	1~96
Degenerated	30(0.12)	64	2.13	1~27
Calcified	223(0.88)	571	2.56	1~96
Total	256(1.01)	643	2.51	1~96

DISCUSSION

Korea has long been known as endemic area of taeniasis. The prevalence, as revealed by egg positive rates in stool examinations, had been recorded as 1.9% in 1971, 0.7% in 1976, 1.1% in 1981 and 0.25% in 1986 (Korea Association of Parasite Eradication). The proportional ratio of *Taenia saginata* to *T. solium* is approximately 5 : 1 with reference to species identification of gravid proglottids or scolecex (Eom, 1991). The proportion of people who eat raw pork

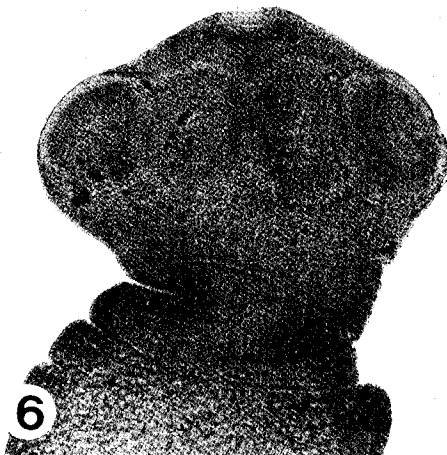
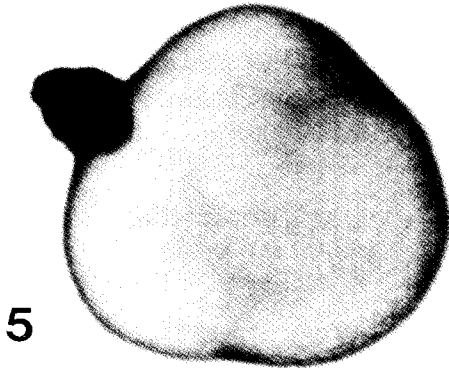
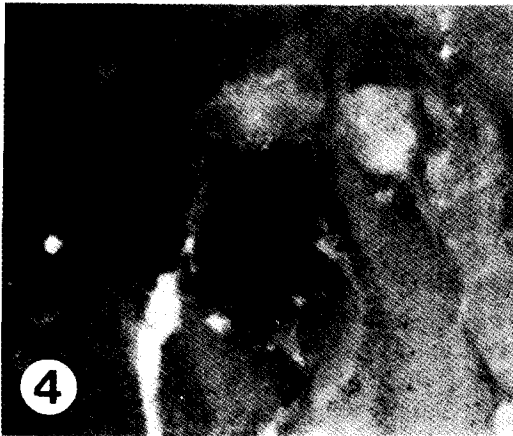


Fig. 4. The calcified scolex of a metacestode ($\times 20$).

Fig. 5. A living metacestode with half-evaginated scolex ($\times 20$).

Fig. 6. The scolex of a metacestode with four suckers ($\times 50$).

compared to those who eat raw beef, however, is approximately 1 : 1. This contradictory epidemiological status raised some questions about the infection source of *T. saginata*. Today *T. saginata* metacestodes are rarely found despite their relatively high prevalence in the past (Nakanishi, 1926). A few recent studies by Hong *et al.* (1983) and Soh *et al.* (1988), therefore, give good reason to doubt that domestic pigs, whose viscera may be eaten raw by some Korean people, are a possible intermediate host of *T. saginata* (-like cestode).

In our study, the livers of 1.01% (256/25,358) of domestic pigs were infected naturally with Asian *T. saginata* metacestodes. Because we selected the livers of pigs by surface examination, the real infection rate seems to be higher than 1.01%.

In Taiwan, Chung *et al.* (1987) reported the diameter of host tissue capsules as 3.17 mm in a range of 1.0~5.0 mm ($n=14$, S.D. 1.1). Our data show a similar size that measured 3.95 mm diameter in a range of 1.0~16.0 mm ($n=414$, S.D. 2.6). With the above features and the existence of rudimentary hooklets in some metacestodes, it is regarded to be the same metacestodes. The detailed morphology will be described elsewhere.

One epidemiological problem that should be explained is the significance of the liver as a source of human infection. The pigs examined in this survey were reared almost uniformly for 6 months. In the livers of these pigs, we found that over 98.8% of the recovered Asian *T. saginata* metacestodes were either calcified or highly degenerated. If we postulate that Asian *T. saginata* metacestodes develop from eggs for 1 month, the metacestodes we recognized in the liver had been infected for 1 to 5 months. In this short period of infection, all but a very few died. This is not a common feature in metacestodes of either *T. saginata* which live in the muscles of pigs or cattle for longer than a year. Even if very few Asian *T. saginata* metacestodes are alive in the liver, the liver can still be a source of human infection. But chances of

human infection should be very low. This fact of quickly dying Asian *T. saginata* metacestode in the livers of the pigs raised a question that there may be other tissues where Asian *T. saginata* metacestodes are maintaining patent infection for a longer period.

This study has confirmed the original findings of Fan *et al.* (1986 & 1987) who established the liver of pigs is a source of human infection with *T. saginata*-like cestode (now tentatively called *T. saginata taiwanensis*). We can now explain the enigmatic relation between the habit of eating raw liver and the infection of Asian *T. saginata*. Since wild boars are unusual and the Lanyu pigs are non-existent in Korea, we believe domestic pigs have been the infection source of Asian *T. saginata*.

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＝국문초록＝

우리나라 돼지 肝臟內 *Asian Taenia saginata* 囊尾蟲의 自然感染

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충북 청주시 소재 도축장에서 6개월령 규격돈 (Yorkshire, Landrace, Duroc 및 Hampshire의 교잡종)을 조사하여 *Asian Taenia saginata* 囊尾蟲의 간장내 감염률을 조사하였다. 낭미충은 1.01% (256/25,358 마리)의 돼지에서 발견되었으며 낭미충의 상태는 살아있었거나 (0.01%, 3/25,358), 죽은 후 번성되어 있었거나 (0.12%, 30/25,358), 석회화된 (0.88%, 223/25,358) 상태로 검출되었다. 감염된 돼지간 중 석회화된 낭미충만 발견되는 경우가 87.1% (223/256)로 대부분이었다. 간장내에서는 우측엽 (14.7%), 우중엽 (29.9%), 좌중엽 (28.2%), 좌측엽 (27.1%)에 고르게 분포하였고, 표면과 실질에도 각각 45.8% 및 54.2%로서 고르게 분포하였다. 낭미충의 크기는 생존상태에서 2.07~2.14×1.98~2.01 mm이었고, 不規則小鉤(rudimentary hooklets)는 17.0%(8/47)의 낭미충에서 발견되었다.

이상의 결과는 돼지에 자연 감염된 *Asian Taenia saginata* 囊尾蟲이 이제까지 무구조충(*Taenia saginata*)으로 오인되었던 *Asian Taenia saginata*의 인체 감염원이 되었을 것으로 생각되었다.

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