

STUDIES ON ABNORMALITY OF METACESTODES AND ADULT WORMS OF *TAENIA SOLIUM* AND *TAENIA SAGINATA ASIATICA* IN RODENTS AND PIGS

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Abstract. Abnormalities are not uncommon in *Taenia saginata* and *T. solium*. After examining 328 mature proglottids from 2 adult worms from two experimentally infected hamsters, 13 (4.0%) were found to have no genital pore but with numerous testes and several vas efferentes; 1 (0.3%) one genital pore with one reproductive system; 12 (3.7%) one on each side with two sets of reproductive system; 17 (5.2%) two on one side with 2 sets of reproductive system; 8 (2.4%) one on one side and two on the other side with 3 sets of reproductive system; 2 (0.6%) two on each side with 4 sets of reproductive system; 4 (1.2%) three on one side with 3 sets of reproductive system, and 4 one on one side and three on the other side with 4 sets of reproductive system. Nine evaginated abnormal cysticerci of *T. s. asiatica* from three experimentally infected SCID mice each had two protoscolexes and a big bladder. From two experimentally infected pigs, one abnormal cysticercus was observed to have two invaginated canals each in one end. Another one had a neck-band behind the scolex and a big bladder. This paper is not only the first report of abnormality of *T. solium* from hamster but also the first one of abnormal cysticerci of *T. s. asiatica* from pigs and mice.

INTRODUCTION

Various abnormalities are common in *Taenia saginata* and *T. solium* and these aberrant forms have caused considerable confusion; they are sometimes identified as new species (Belding, 1965). The abnormalities include total or partial melanism, conditions in which the number of scolexes is more than one and that suckers are more than four (Thatcher, 1972; Chung *et al*, 1994). Abnormal strobilae, double sets of reproductive organs have also been reported (Andry, 1714; Laker, 1885; Rosenberger, 1903; McCulloch, 1913; Foster, 1915; Faust, 1925; Burrows and Klink, 1955; Pezenburg and Oleck, 1955; Hock, 1965; Cheong, 1965; Thatcher, 1972). *T. saginata* with bilateral genital pores have been reported by Merdivenci (1964) in Turkey, Cho *et al* (1967) in Korea and Velasquez and Chanco (1969) in the Philippines, Huang (1967) and Chung (1982) in Taiwan. Triplicate genital pores have also been recorded (Chung, 1982).

Moreover, Chung *et al* (1994) reported the first case of triradiate Taiwan *Taenia* from an Atayal aborigine. Rashed *et al* (1992) reported a ratio of one triradiate to 5,620 normal adult worms of *T. pisiformis* in dogs and a prevalence of 0.02% for the triradiate forms in the parasite population. In addition, abnormal metacestodes have also been reported in *T. crassiceps* (Schiller, 1973) and *T. solium* (Molinari *et al*, 1992). Moreover, at times, abnormal fenestrated proglottids and scolices of *T. solium* with a variable number and arrangement of hooks and suckers have also been encountered (Belding, 1965).

By experimental infection, Esch (1968) found a significant higher incidence of nervous system infections in mice given normal eggs of *T. multiceps* than those given anomalous ones. Among abnormality of *T. saginata*, polyradiate worms are relatively common. There were at least 25 cases of polyradiate *T. saginata* from Europe, America, and Africa (Chung *et al*, 1994). In addition, a case of triradiate Taiwan *Taenia* was found in a 38-year-old male Atayal aborigine in Taiwan. The triradiate tapeworm was 342 cm in length. There were six suckers in the scolex. It was uniformly triradiate throughout its entire length. Moreover, the size of eggs of the triradiate worm was larger than those of the normal ones (Chung *et al*, 1994).

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In our laboratory study on both *T. solium* and *T. s. asiatica*, we found abnormalities in the proglottids of *T. solium* from a hamster (Wang *et al.*, 1999). We also found abnormal evaginated cysticerci of *T. s. asiatica* in three immunodeficiency (SCID) mice (Wang *et al.*, 2000). In addition, we also reported the abnormal cysticerci of *T. s. asiatica* in two SEM pigs (Fan *et al.*, 1999).

MATERIALS AND METHODS

Collection of abnormal mature proglottids of *T. solium*

An adult *T. solium* was collected from a clinical case with cysticercosis and taeniasis solium in Cystercosis Hospital, Zhengzhou City, Henan Province, Mainland China by chemotherapy with a mixture of areca and pumpkin seeds. This worm was intact but without scolex. It was sent immediately to our laboratory in Taipei by air mail.

Eggs were collected from the last ten gravid proglottids of the tapeworm. These eggs were hatched by an enzyme method (with our modifications and their viability was determined by color changes in 0.4% trypan blue solution (Wang *et al.*, 1997). Oncospheres were subcutaneously injected to SCID mice. The SCID mice were kept in autoclaved (100°C for 1 hour) cages with autoclaved wood shaving bedding and covered with a filter cap. Food and drinking water were also autoclaved and provided *ad libitum*. These mice were sacrificed by lethal ether administration. After removing the skin, cysticerci were recovered from the subcutaneous tissues.

Four Syrian hamsters, administered subcutaneously with triamcinolone acetonide (Sinicort) (Lin Inc) in a dosage of 10 mg/10 days, were fed each with 3 cysticerci wrapped up in mouse muscles. These animals were sacrificed by lethal ether administration 40 days after infection. Two adult worms of *T. solium* were collected from the intestinal tract of two hamsters and examined using the methods employed in our previous study (Wang *et al.*, 1999).

Collection of abnormal cysticerci of *T. s. asiatica* from SCID mice

Adult worms of *T. s. asiatica* were collected from two Taiwan-aboriginal cases. The eggs collected from the last ten gravid proglottids of the tapeworms were hatched and viability determined as described above. Ten SCID mice each were inoculated subcutaneously with 39,000 oncospheres of *T. s. asiatica*. After experimental infection, the mice were treated as above mentioned (Wang *et al.*, 1999).

All infected SCID mice were sacrificed after ether anesthesia of various intervals (38-244 days) after infection. The mice were examined carefully and the number and locality of cysticerci recovered were recorded. A total of 5,899 cysticerci were collected, examined, and measured by the methods used for the experimental infection of Korean *Taenia* (Fan *et al.*, 1989). Nine abnormal cysticerci were found from 3 infected SCID mice (Wang *et al.*, 1999).

Collection of abnormal cysticerci of *T. s. asiatica* from experimentally infected pigs

Adult worms of *T. s. asiatica* were recovered from the aboriginal patients with taeniasis in mountainous areas of northeastern Taiwan after chemotherapy with atabrine. *In vitro* hatching of eggs and activation of oncospheres were carried out using the method described by Wang *et al.* (1997). These oncospheres were then inoculated to 2 SEM pigs through a stomach tube. Cysticerci were obtained from the pigs after sacrifice. The methods employed for experimental inoculation, necropsy of infected animals, examination of cysticerci, and the classification of cysticercus development were the same as those used for experimental infection of the Korea *Taenia* (Fan *et al.*, 1989). Two abnormal cysticerci were found from 2 pigs.

RESULTS

Abnormal mature proglottids of *T. solium* collected from a hamster

Five adult *T. solium* were collected from the small intestine of 3 immunosuppressed Syrian golden hamsters 21-122 days post-infection. These worms had 157-809 (157-638 immature and 171 mature) proglottids and measured 5.9-45 cm long (Table 1).

After examining 328 mature proglottids from 2 adult worms, 13 (4.0%) were found to have no genital pore but with numerous testes and several vas efferents (Fig 1). Other findings were: 1 (0.3%) one genital pore with two sets of reproductive system (Fig 2), 12 (3.7%) one on each side with 2 sets of reproductive system (Fig 3), 17 (5.2%) two on one side with 2 sets of reproductive system (Fig 4), 8 (2.4%) one on one side and two on the other side with 3 sets of reproductive system (Fig 5), 2 (0.6%) two on each side with 4 sets of reproductive system (Fig 6), 4 (1.2%) three on one side with 3 sets of reproductive system (Fig 7), and 4 (1.2%) one on one side and three on the other side with 4 sets of reproductive system (Fig 8, Tables 2 and 3).

Abnormal cysticercus of *T.s. asiatica* from experimentally infected SCID mice

Three evaginated abnormal cysticerci of *T. s.*

Table 1
Measurement of five worms of *Taenia solium* in three hamsters.

Hamster no.	Worm no.	Length (cm)			Proglottid no.			Days of infection
		Mature	Immature	Total	Mature	Immature	Total	
1	1	21.5	23.5	45	157	487	644	40
	2	0	14.7	14.7	0	157	157	40
2	1	14.1	16.3	30.4	171	638	809	122
	3	0	6.4	6.4	0	639	639	21
Total	5	0-	5.9-	5.9-	0-	157-	157-	21-
		21.5	23.5	45	171	638	809	122

Table 2
Count of genital pores on mature proglottids in two worms of *Taenia solium*.

Worm no.	No. of mature proglottid examined	No. of genital pores on both sides/proglottid							
		0	1	1-1	0-2	1-2	2-2	0-3	1-3
1	157	10(1) ^a	1 ^b	7	10	3	1	2	2
2	171	3		5	7	5	1	2	2
Total	328	13 ^c	1	12	17	8	2	4	4
%		4.0	0.3	3.7	5.2	2.4	0.6	1.2	1.2

^aNumerous testes and several vas efferents were found; ^bTwo sets of reproductive system were found;

^cMost of them had small size.

Table 3
Count of the set of reproduction system in 328 mature proglottids of *Taenia solium*.

Reproductive system/proglottid	No. of genital pores on both sides/proglottid								
	0	1	1-1	0-2	1-2	2-2	0-3	1-3	
No. of proglottids	13	1	12	17	8	2	4	4	
Set of reproductive system	0	2	2	2	3	4	3	4	

asiatica were found among 1,794, 529, and 649 cysticerci 62, 118, and 145 days post-infection respectively from three SCID mice. Each of the nine evaginated abnormal cysticerci had two protoscoleces and a big bladder (Wang *et al*, 2000) (Fig 9).

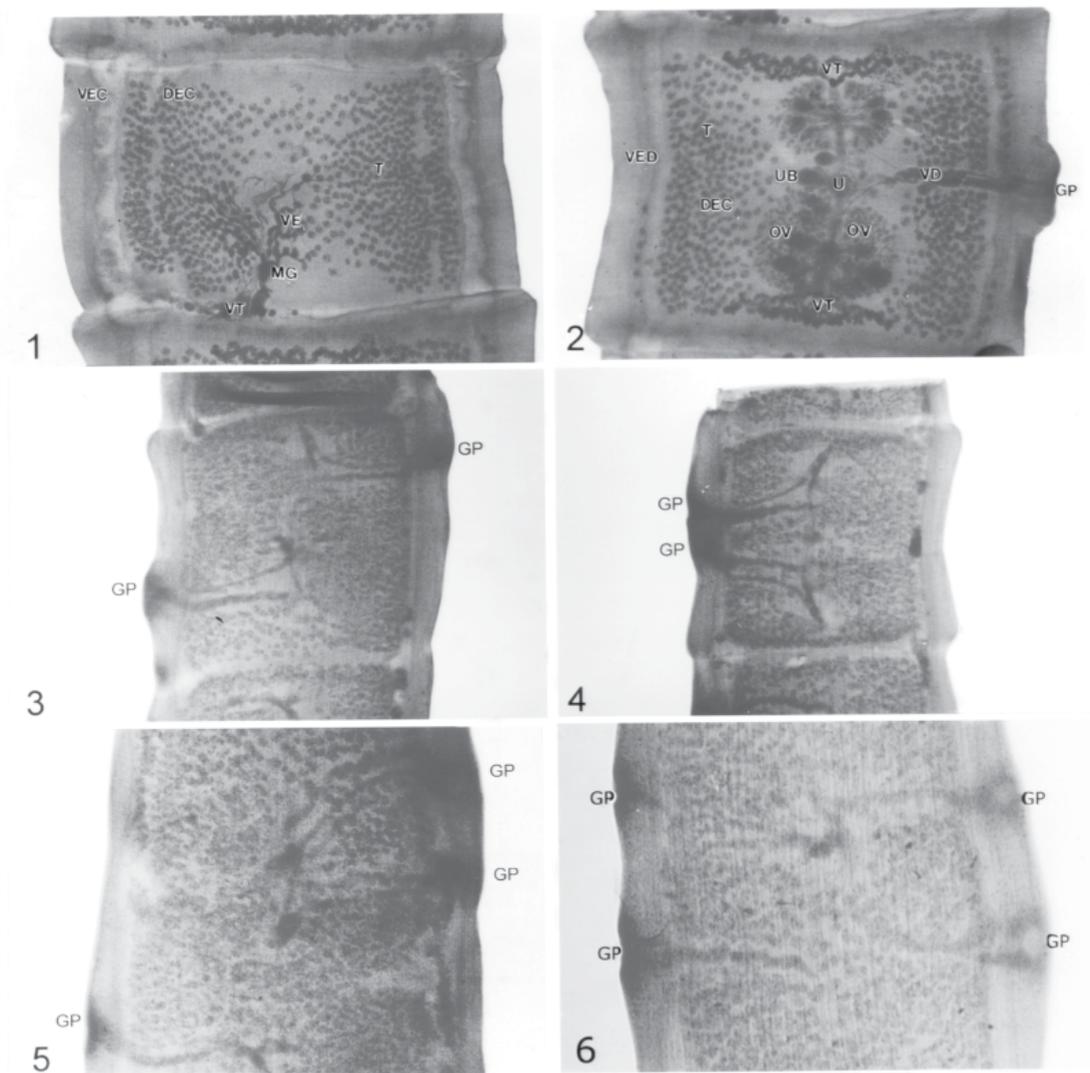
Abnormal cysticercus of *T. s. asiatica* from experimentally infected pigs (SEM strain)

An abnormal cysticercus of *T. s. asiatica* was observed to have four suckers and two invaginated canals which was found among 415 cysticerci 92 days after infection from a SEM pig (Fig 10). Another

abnormal scolex had four suckers, a neck-band and a big bladder which was found among 2,169 cysticerci 42 days post-infection recovered from a SEM pig (Fan *et al*, 1989) (Fig 11).

DISCUSSION

Morphological abnormalities of the scolex has been reported in *T. crassiceps* with an atypical number of suckers, double rostellata, and aberrant rostellar hooks (Schiller, 1973). An unusual oncosphere of *O. bivitellobata* with 12 larval hooks has been described

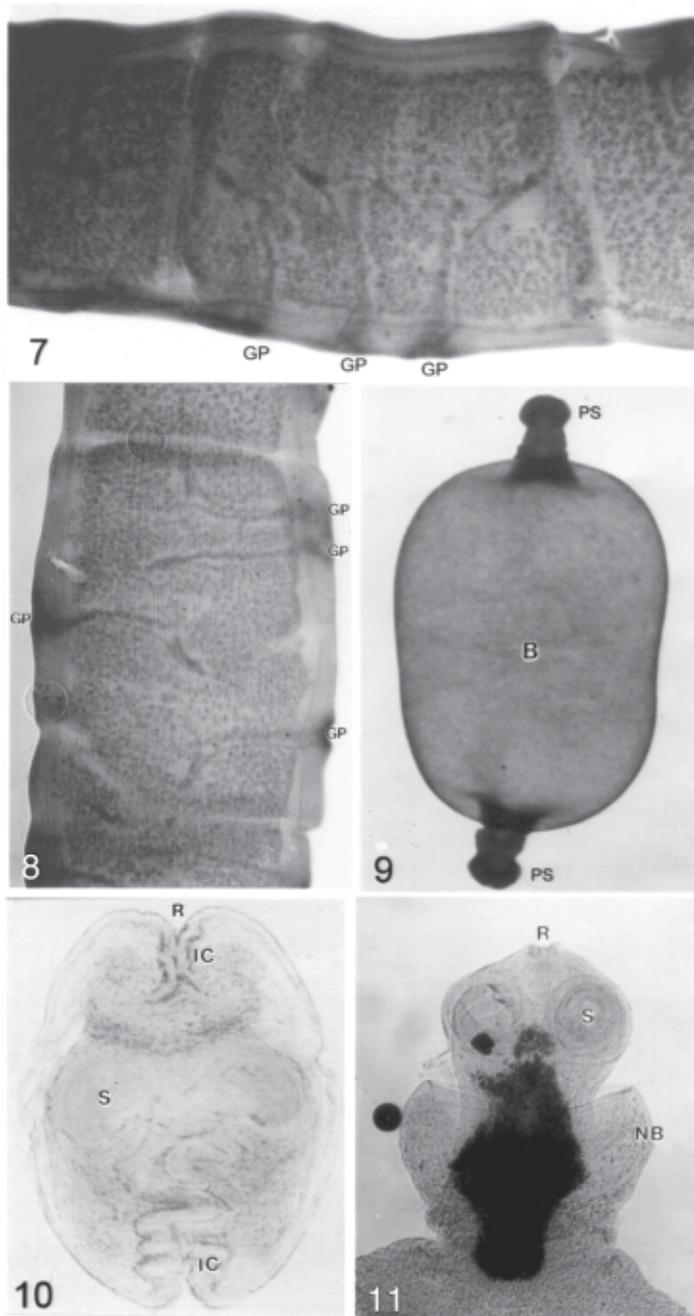


Figs 1-11- Showing the abnormality of *Taenia solium* and *Taenia saginata asiatica*. (All abnormal specimens were stained with alum carmine except three abnormal cysticerci cleared with cresol only). Figs 1-8 collected from 2 hamsters. Fig 9 from a SCID mouse. Figs 10 and 11 from 2 SEM pigs.

1. A mature segment had numerous testes and several vas efferents but no genital pore was found (13x).
2. A mature segment with single genital pore and 2 sets of reproductive organs (13x).
3. A mature segment had 2 genital pores 1 in each side and 2 sets of reproductive organs (8x).
4. A mature segment had 2 genital pores in left side and 2 sets of reproductive organs (7x).
5. A mature segment had 3 genital pores (1 in left side another 2 in right side) and 3 sets of reproductive organs (10x).
6. A mature segment had 4 genital pores (2 in each side) and 4 sets of reproductive organs (11x).

by Loewen (1985). Molinari *et al* (1992) reported two cysticerci containing two scolices among several thousand *T. solium* metacestodes dissected from swine. In this study, abnormal mature proglottids were found in two adult worm of *T. solium* in two experimentally infected hamsters. This is the first report of abnormality of *T. solium* from rodent. Moreover, we

not only found two abnormal cysticerci among 122,435 *T. s. asiatica* metacestodes in experimentally 132 infected pigs but also found nine abnormal *T. s. asiatica* each with two protoscolices from 5,899 cysticerci in 10 experimentally infected SCID mice. These findings are the first reports of abnormal cysticerci of *T. s. asiatica* from pigs and mice.



7. A mature segment had 3 genital pores in left side and 3 sets of reproductive organs (9x).
8. A mature segment had 4 genital pore (1 in left side and 3 in right side) and 4 sets reproductive organs (8x).
9. An evaginated cysticercus had two protoscolexes on each end and a big bladder (14x).
10. An abnormal cysticercus had 4 suckers and 2 invaginated canals, one on each end (25x).
11. An abnormal cysticercus had a scolex (4 suckers), a neck-band and a big bladder (120x).
 B - bladder, DEC - dorsal excretory canal, GP - genital pore, IC - invaginated canal, NB - neck-band, O - ovary -
 PS - protoscolex, R - rostellum, T - testes, U - uterine, UB - uterine branch, V - vagina, VE - vas efferents, VEC
 (VED) - ventral excretory canal (ve duct), VT - veterlaria.

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