

EXPERIMENTAL STUDIES ON SMALL HOOKS PRECEDING LARGE HOOKS IN THE GROWTH AND DEVELOPMENT OF *TAENIA SOLIUM* METACESTODES

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Abstract. In the present study, we have determined the growth and development pattern of rostellar hooklets of *Taenia solium* cysticerci (Zhengzhou and Harbin strains) in three pigs (1 SEM and 2 L-SEM strains) 89-196 days post experimental infection. A total of 3,675 cysticerci were collected from 3 pigs, 3,007 (82%) of 3,675 cysticerci were evaginated by enzyme method. 439 (15%) evaginated cysticerci were carefully examined and measured after dehydration, staining, and mounting on microscopic slides. Among 439 cysticerci, 234 (53%) had pair rostellar hooks, 88 (20%) with unpair hooks, 60 (14%) only small (outer row) hooks, and 57 (13%) no hooks including 34 hooks were completely dropped and 23 no hooks developed. The number ranged from 10 to 17 pairs for pair hooks and 1 to 29 for unpair ones. The length and width of rostellar hooks on the scolex of cysticerci were usually larger in the pig with longer infection time. Moreover, cysticerci with pair and unpair rostellar hooks had only small hooks and no hooks were present on their scolices. However, cysticerci with only large (inner row) hooks were not found. These findings indicate that the growth and development of small hooks precedes that of the large hooks in the formation of the two-row pattern rostellar hook in *Cysticercus cellulosae*.

INTRODUCTION

Although the larval stage of *Taenia solium* may develop in goat, sheep, cattle, horse, dog, deer, cat, bear, rat or monkey, pig is the most important intermediate host for this tapeworm (Soulsby, 1968; Fan *et al*, 1994). The development of *Cysticercus cellulosae* in pig have been studied by Yoshino (1933). After ingestion of *T. solium* eggs, the oncospheres hatch in the intestine. The emergent oncospheres penetrate through the intestinal wall into mesenteric venules and are carried throughout the body. Most of the

oncospheres filter out between the muscles and develop into the mature cysticerci in 60-70 days.

The double rows of rostellar hooks on the scolex is an important distinguishing characteristic of *C. cellulosae*. However, the information concerning this aspect is not abundant and the pattern of rostellar hooks during the growth and development of *C. cellulosae* remained unclear. Recently, we obtained three adult worms of *T. solium* from three patients with cysticercosis and taeniasis solium following chemotherapy with a mixture of areca and pumpkin seeds in the King-Shui Hospital, Zhengzhou City, Henan Province, China. These worms were then mailed to our laboratory in Taipei. We conducted further experimental infections in different strains of pigs (Fan *et al*, 2000a, b). In this paper, we report the rostellar hooks grow and develop pattern of

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Taenia solium metacestodes in pigs after experimental infection.

MATERIALS AND METHODS

Eggs were collected from the last 10 gravid proglottids of these worms. To each of 1 Small-Ear-Miniature (SEM) and 2 Landrace Small-Ear-Miniature (L-SEM) pigs, 39,000 *T. solium* eggs were administered orally. The animals were then kept in our animal center and fed a regular diet.

These pigs were killed 89-196 days post experimental infection. After sacrifice cysticerci were very carefully collected from various parts of the carcasses of one SEM spending 8 days, one L-SEM pig, 12 days, and another L-SEM pig, 16 days by two senior research technicians. The methods of necropsy of infected animals and examination of cysticerci were the same as those used in our previous study for the experimental infection of Korean *Taenia* (Fan *et al.*, 1989).

RESULTS

Rostellar hook pattern

A total of 3,675 cysticerci were collected from the three pigs and 3,007 (82%) were found to be evaginated in pig bile (Fan *et al.*, 2000b). Among the evaginated cysticerci, 439 cysticerci were measured and counted after

dehydration, staining, and mounting on microscopic slides. Most of these cysticerci (53%) had pair rostellar hooks and the 10-17 pair rostellar hooks were found. The remaining ones had only small (outer row) hooks (14%), unpair hooks (20%), or no hooks (13%). In the cysticerci with no hooks, 23 did not developed any hooks and the hooks in 34 dropped completely. Cysticerci with pair rostellar hooks, had no hooks, only small hooks (outer row), unpair or large (inner row) and small hooks (outer row) on their scolices were found. Cysticerci with only large hooks were not found (Table 1; Figs 1-26).

Measurement and count of unpair rostellar hooks

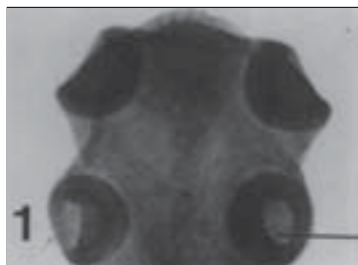
The number of unpair hooks ranged from 1 to 29. The mean length and width of large and small hooks obtained from the 130-day infected pig were 140 (110-160) μm x 20 (15-23) μm and 105 (55-125) x 14 (10-19) μm , respectively. The corresponding figures from the 196-day infected pig were 144 (100-175) μm x 20 (15-25) μm and 116 (90-135) μm x 14 (10-20) μm , respectively. In total, the mean length and width of large and small hooks were 142 (100-175) μm x 20 (15-25) μm and 111 (55-135) x 14 (10-20) μm , respectively. The ratio of large hook to small hook was 1:1.3 (Table 2).

Measurement and count of rostellar hooks

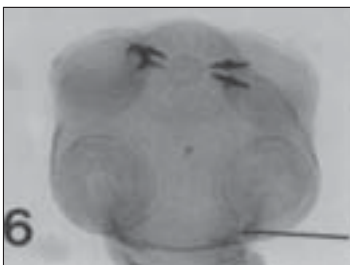
The number of pair rostellar hooks ranged

Table 1
Rostellar hook pattern of *Taenia solium* metacestodes.

	Rostellar hook		Remarks
	No. examined	%	
No hook found	57	13	34 hooks completely dropped, 23 no developed yet
Small hooks only	60	14	
Unpair hooks	88	20	
Pair hooks	234	53	10-17 pair hooks
Total	439	100	



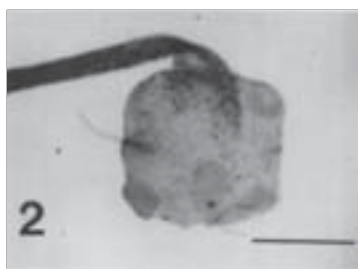
1 No hooks due to dropped up completely.



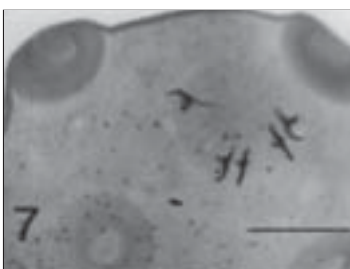
6 Four small hooks.



11 Nine small hooks.



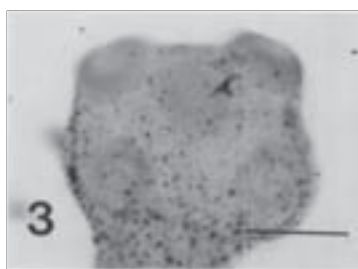
2 No any hook developed yet.



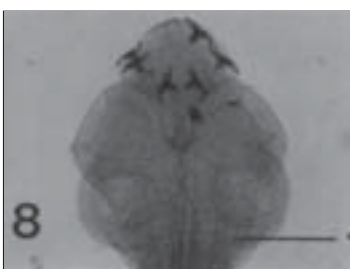
7 Five small hooks.



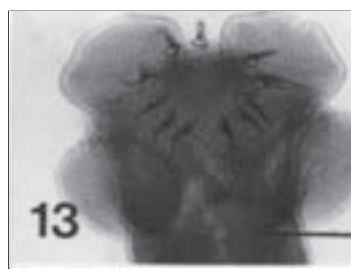
12 Ten small hooks.



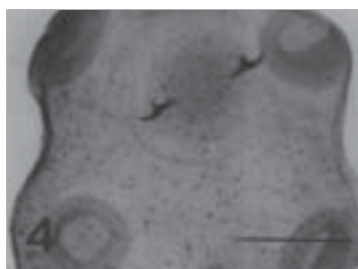
3 One small hook.



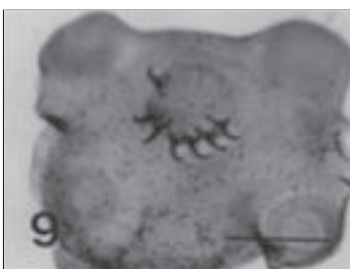
8 Six small hooks.



13 Eleven small hooks.



4 Two small hooks.



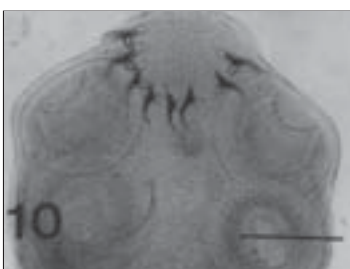
9 Seven small hooks.



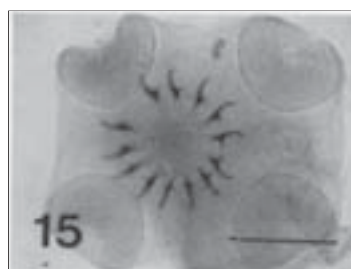
14 Twelve small hooks.



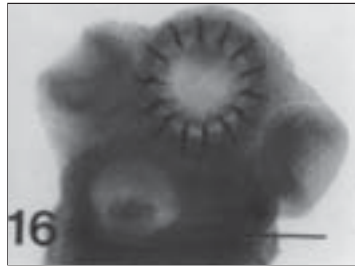
5 Three small hooks.



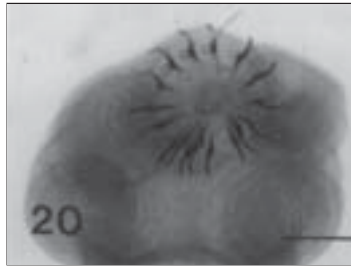
10 Eight small hooks.



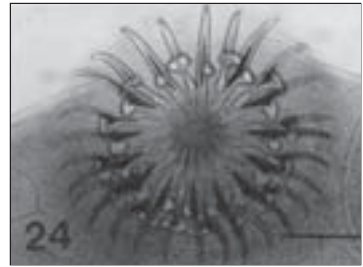
15 Thirteen small hooks.



Fourteen small hooks.



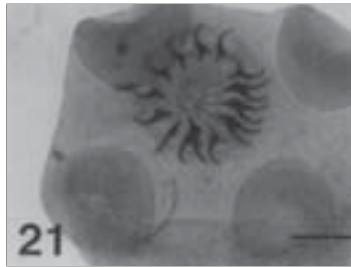
Three large and 14 small hooks.



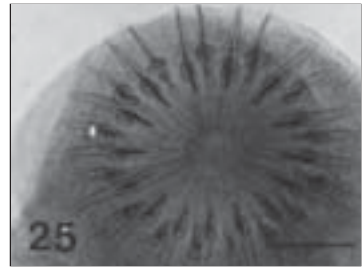
Fourteen pair hooks.



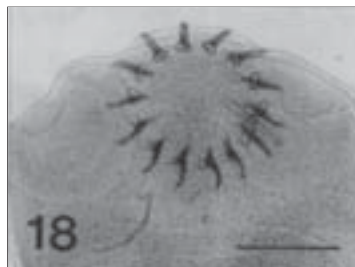
Fifteen small hooks.



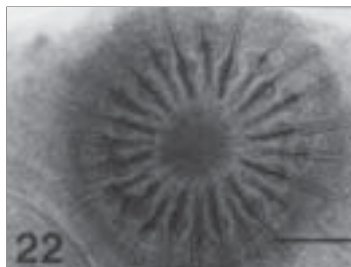
Four large and 13 small hooks.



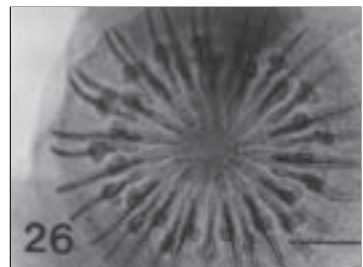
Fifteen pair hooks.



One large and 14 small hooks.



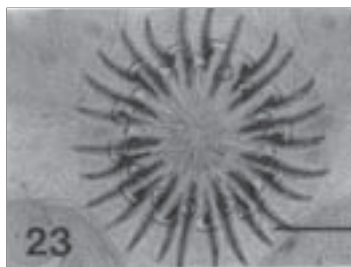
Twelve pair hooks.



Sixteen pair hooks.



Two large and 12 small hooks.



Thirteen pair hooks.

Fig 1-26—Showing the rostellar hooks of *Taenia solium* cysticeri.

Fig 1-17—The small rostellar hooks only (Bar = 100 μ m).

Fig 18-22—The unpair rostellar hooks (Bar = 100 μ m).

Fig 23-26—The pair rostellar hooks (Bar = 50 μ m).

from 10 to 17. The mean length of large and small hooks obtained from the 89-day infected pig were 111 (70-175) μ m and 57(30-100) μ m, respectively. The mean length and width of large and small hooks obtained from the 130-day infected pig were 144 (90-165)

μ m x 18 (15-25) μ m and 106 (60-140) μ m x 14 (10-15) μ m, respectively. The corresponding figures from the 196-day infected pig were 153 (120-200) μ m x 19 (15-25) μ m and 112 (65-135) μ m x 15 (10-20) μ m, respectively. Totally, the mean length and width

Table 2
Measurement and count of unpair or large and small rostellar hooks of *Taenia solium* metacestodes.

Serial no. of hooks	Days of infect	No. exam	Large hook (μm)			Small hook (μm)		
			No.	Length	Width	No.	Length	Width
1-5	130 ^a	3	0			3	62/55-70 ^c	13/10-15
	196 ^b	23	0			23	117/110-130	16/10-20
6-10	130	4	5	117/110-125	20/20-20	2	100/100-100	13/10-15
	196	36	6	139/125-175	23/20-25	33	115/100-130	16/10-20
11-15	130	9	4	148/115-160	19/15-20	9	118/100-125	15/13-15
	196	46	16	136/100-165	19/15-20	40	113/90-130	14/10-20
16-20	130	4	4	140/115-155	21/20-23	4	107/90-115	16/13-19
	196	12	12	154/150-165	21/15-23	12	118/100-130	14/10-15
21-25	130	3	3	155/155-160	20/15-23	3	113/110-120	15/14-15
	196	5	5	160/160-160	18/15-20	5	126/125-130	11/10-15
26-29	130	0	0			0		
	196	3	3	133/115-150	17/15-20	3	99/95-100	14/14-14
Total (1-29)	130	23	16	140/110-160	20/15-23	21	105/55-125	14/10-19
	196	125	42	144/100-175	20/15-25	116	116/90-135	14/10-20

^aA L-SEM pig (No. 1), ^bA L-SEM pig (No. 2), ^cmean/range.

of large and small hooks were 136 (70-200) μm x 19 (15-25) μm and 92 (30-140) μm x 15 (10-20) μm , respectively. The ratio of large to small hooks was 1:1.5 (Table 3).

DISCUSSION

The development of rostellar hooks on the scolex of *C. cellulosae* has been described by Okabe (1957). The hooks are originally short and pin-like 40 days after infection. They then develop into ordinary hook-form and form double concentric circular rows. The inner circle is made of larger hooks and the outer is of smaller ones. Each hook of both circles is situated alternately. The numbers of hooks ranged from 22 to 28. The larger hooks are 128-162 μm in length and the small ones 100-125 μm . Moreover, the numbers of rostellar hooks of cysticerci in pigs have been studied by Eshinu (1933), Masuda (1965), Slais (1970), Soulsby (1982) and Kim (1985). The numbers reported were 28, 26, 26, 22-32 and 26-31, respectively. In our previous study, we found cysticerci with

27 (20-36) rostellar hooks in pigs (Fan *et al*, 1994).

The measurements of rostellar hooks of *T. solium* cysticerci in pigs have also been investigated by Okabe (1957), Verster (1967), Soulsby (1968), and Kim (1985). The length of large and small hooks has been reported to be 128-162 μm and 100-130 μm by Okabe (1957), 160-170 μm and 110-140 μm by Verster (1967), 140-180 μm and 110-140 μm by Soulsby (1968), respectively. Kim (1985) reported that large hooks measured 136-187 μm . In our previous study, we have found that the mean length of large and small hooks were 147 μm (90-235 μm) and 94 μm (50-125 μm) in two infected pigs. In dogs, the mean lengths of large and small hooks were 137 μm (120-180 μm) and 96 μm (65-125 μm), respectively (Fan *et al*, 1994). In our more recent report, the mean length of large and small hooks were 141 μm (123-180 μm) and 90 μm (75-130 μm) respectively (Fan *et al*, 2000a).

In the present study, we found that the length of rostellar hooks on the scolex of cysticerci was larger in the pig with longer

Table 3
Measurement and count of pair large and small rostellar hooks of *Taenia solium* metacestodes in three pigs.

No. pairs	Days of infection	No. exam	Large hook (μm)		Small hook (μm)	
			Length	Width	Length	Width
10	89 ^a	21	117/70-175 ^d	ND	58/40-80	ND
	130 ^b	2	128/115-140	20/15-25	68/65-70	15/15-15
	196 ^c	9	152/150-160	19/15-24	112/90-125	15/10-20
11	89	15	104/70-110	ND	57/30-75	ND
	130	3	152/150-155	20/19-23	102/75-120	16/15-18
	196	9	145/125-175	20/15-25	105/75-120	16/15-20
12	89	10	105/70-140	ND	54/40-80	ND
	130	3	148/140-155	18/16-20	108/100-120	15/14-15
	196	22	151/120-175	19/15-25	108/65-130	15/10-20
13	89	18	108/75-130	ND	54/40-80	ND
	130	13	143/90-165	18/16-20	100/60-130	14/10-19
	196	30	154/135-170	18/15-25	113/65-135	13/10-15
14	89	13	101/75-125	ND	56/50-70	ND
	130	13	146/120-155	18/15-25	115/80-140	15/10-16
	196	20	155/135-170	20/16-25	116/90-130	16/10-20
15	89	12	131/80-140	ND	58/50-75	ND
	130	9	141/130-160	17/15-30	109/80-120	14/10-15
	196	4	166/150-200	18/15-20	111/105-125	14/10-15
16	89	3	128/80-150	ND	82/50-100	ND
	130	0				
	196	1	150/150	20/20	115/115	15/15
17	89	4	105/75-130	ND	59/50-75	ND
	130	0				
	196	0				
Total	89	96	111/70-175	ND	57/30-100	ND
10-17	130	43	144/90-165	18/15-25	106/60-140	14/10-15
	196	95	153/120-200	19/15-25	112/65-135	15/10-20

^aA SEM pig, ^bA L-SEM pig (No. 1), ^cA L-SEM pig (No. 2).

^dMean/range; ND - Not done.

infection time. However, width of the hooks was similar in the three pigs even in different infection time. Moreover, *C. cellulosae* may have unpair and pair rostellar hooks, although most of the hooks are pair. Among the cysticerci with unpair hooks, we found those with large and small hooks, only small hooks, or no hooks on their scolices. However, cysticerci with only large hooks were not found. These findings indicate that the growth and development of small hooks precedes that of the large hooks in the formation of the two-row pattern of rostellar hooks in *C.*

cellulosae. This phenomena is probably also presented in the metacestodes of *T. taeniaformis*, *T. hydatigena*, *T. ovis*, *T. pisiformis*, *T. multiceps*, *T. serialis*, and *T. gigeri*.

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