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# STUDIES ON *TAENIA* SPECIES PREVALENT AMONG THE ABORIGINES IN WULAI DISTRICT, TAIWAN

## Part II

## ON THE SPECIES OF *TAENIA*[1]

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## ABSTRACT

Sixty-four specimens of tapeworms, 28 with and 36 without scolices, obtained by treating infected aborigines in Wulai district, were examined. All specimens were morphologically identical to *Taneia saginata,* except one unusual abnormality. The specimen revealed a complete fusion of the *T. saginata* at their lateral margins. Two calves less than 7 days old were experimentally infected with the worm ova in the segments. However, the obtained cysticerci were different from ordinary *Cysticercus bovis* in size and site of parasitation. The cattle seemed not to be the natural intermediate host of *T. saginata* in Taiwan. The possible chain-of-life cycle of the worm on this island was discussed.


## INTRODUCTION

Taeniasis is highly prevalent among the aborigines in Taiwan. Yokogawa, in 1932, reported that more than 20% of the aborigines in northern Taiwan were infected (1), Huang *et al.,* in 1952, also reported that the incidence of taeniasis for the aborigines in Wulai district was 20.5% (2). Bergner *et al.,* in 1964, reported that the incidence of taeniasis for the villagers of Hapung in Wulai district was as high as 27% (3). The present author made a survey of 5 villages in Wulai district recently. The average infection rate for *Taenia* species was found to have increased to 28.24% (4).

One hundred specimens of tapeworms obtained by treating infected aborigines in northern Taiwan were examined by Yokogawa in 1932. He reported that majority of them were identical to *T. saginata* but that a few were similar to *T. confusa* (5). The infection of *T. saginata* is known to be acquired by eating raw or under-done beef. However, the aborigines who live in the mountainous area of this island have only a limited chance to eat beef because of the difficulties of transportation from the lowlands where the beef is being supplied. Besides, the high expense of the beef and poor financial conditions of the aborigines also prevented many of them from eating beef. Therefore, the study of the species of *Taenia* prevalent among the aborigines in Taiwan aroused the author's interest.

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## MATERIALS AND METHODS

Sixty-four tapeworms, 28 with and 36 without scolices, obtained from the aborigines in Wulai district of Taipei prefecture were used in this study. The specimens were washed with several changes of water and were then placed in hot water (65-70 C) for 10 to 30 minutes. When the worms were found to be well relaxed, they were fixed with F.A.A.G. (formalin-acetic acid-alcohol-glycerol) fixative. The scolices, the gravid and mature segments numbering 10 each, were removed from each specimen and were pressed between 2 glass plates. The flattened specimens were stained with Aceto-carmin and were mounted in toto for observation.

Three male calves (*Holstein* strain), 2, 7, and 30 days old, were fed with approximately a million each of the *Taenia* eggs.

The calves were sacrificed 2, 4 and 3 months respectively after the experimental feeding of the eggs and were examined carefully for the presence of cysticerci. The eggs used were tested for their viability by digestion and motility tests as designed by Isobe (6). Only those batches of eggs found to be viable were used.

## RESULTS

I. *Morphological study of the worms*

The entire worm: The entire worm strobila was contracted and looked like a chain of beans when freshly passed. Each segment, especially the gravid one, was contracted to an almost globular shape. The total length of the worms ranged from 0.7 to 1.2 meters in contracted state. The worms extended to 3 or 4 meters when relaxed by immersing in warm water. The number of the proglottids ranged from 673 to 1326.

The scolices: The scolices were pyriform, measuring from 1.1 to 1.3 mm in diameter, and were apparently of equal length in the compressed state. Four prominent hemispherical suckers were found on the scolex but no rostellum nor hooklets were observed. The diameter of the suckers ranged from 0.43 to 0.56 mm and the thickness varied from 0.14 to 0.22 mm. The apical regions of the scolices were convexed and darkly pigmented in 26 out of 28 specimens. The pigmentation could be clearly seen even in fresh specimens. The necks were long and narrow, measuring from 3 to 4 by 0.65 to 0.76 mm. The calcarous bodies were denser over the scolex. There were no marginal elytra. All 28 scolices looked exactly like those of typical *Taenia saginata.*

The mature proglottids: Most of the mature proglottids were quadrangular in shape, measuring from 7 to 10 mm in breadth and slightly shorter in length. The irregularly alternated genital pores were usually seen on the middle of the lateral margins. Numerous testes, numbering from 320 to 460, were scattered over both sides of the segment and were slightly more numerous over the upper part of the segment. The size of testes ran from 0.058 to 0.102 mm in diameter. Seminal vesicles were absent in 55 out of 64 specimens (86%). The ovaries were bilobed and kidney shaped. They were located at the lower part of the segment, one on each side of the tubular uterus. Rectangular or triangular shaped small compacted vitilline glands were usually located at the lower pole of the segment. They were slightly wedged between the two ovaries and were connected with oötypes. The vagina was equipped with a well-developed sphincter. Morphologically, all the specimens were similar to *T. saginata* described by Anderson (7), except one peculiar abnormality which will be described separately.

The gravid proglottids: The gravid proglottids were rectangular in shape and measured 16 to 24 mm long by 6 to 9 mm broad. The number of the lateral branches of the

uterus ranged from 17 to 29, but usually were from 20 to 23. Most of the lateral branches were perpendicular to the main uterine stem. The terminal ends were bifurcated in some. Further branching was also noticed in a few. The branches at the end of the uterus tend to take an oblique course. They broke up very soon into 2 or more branches and in some divided again in a similar way. Therefore, they formed the appearance of a tree. All the gravid proglottids fell in the range of the typical *Taenia saginata*.

The ova: The ova of the worms were in general ovoid in shape, measuring from 0.030 to 0.042 mm along the greatest diameter. Most of the onchosphers contained 6 hooklets but a few were found to have 8 hooklets (2 out of 300). They were surrounded by thick outer shells heavily marked by radical striations. The eggs obtained by gently pressing the gravid proglottids had large delicate, hyaline and thin envelopes. Many of them had long hair-like protrusions, one at each pole of the eggs. These protrusions have been described by Yokogawa as the characteristics of *T. saginata* ova.

The abnormality of *T. saginata*: Among 36 specimens without scolices, one was found to be quite different from the others. In this particular specimen, a longitudinal cord-like elevation was observed at the center of the strobila. Microscopically, there were 2 sets of reproductive organs in each segment, one on each side of the central cord-like elevation. Genital pores were present on both margins in some segments, while, in others, one at the center of the cord-like elevation and the other at the lateral margin. Fusion of the 2 genital pores at the center of the cord-like elevation was also present. Two main uterine stems were distinctly observed in gravid proglottids. The inner terminal ends of the lateral uterine branches were found to fuse at the center of the proglottids just beneath the cord-like elevation. This was a complete fusion of the 2 *T. saginata* at their lateral margins (*Fig. 1*). Similar abnormality was reported by Meridivenci in 1964 (8).

II. *Experimental infection of the calf*

Calf No. 1 (2 days old) was sacrificed 2 months after the experimental feeding of the eggs and was found to be heavily infected. About 3,000 of the cysticerci were found on and within the liver of the calf at autopsy. There were none in muscles, lungs, heart, spleen, nor in bone. The distribution of the cysts seemed to be slightly denser on the surface than in the parenchyma of the liver. Although in muscles and lymphatics there were many blackish spots corresponding to the size of cysticerci, on examination cysticerci were not found. The cysticerci obtained measured 1.5 to 2.0 by 2.0 to 3.8 mm, only 2/5 of the size of the ordinary *Cysticercus bovis* at the corresponding age reported by Uraquhart (9). The tiny pearly white cysts were surrounded by thin but very tough connective tissue. Four well developed, prominent hemispherical suckers were seen on invaginated scolices. The size of suckers measured from 0.21 to 0.31 mm. Among 100 cysticerci examined, 18 were found to have rudimentary hooklets. The hooklets numbered from 16 to 20 and measured from 0.009 to 0.012 mm in length.

Calf No. 2 (30 days old) was destroyed 3 months after the feeding of the eggs. No cysticerci were found at autopsy.

Calf No. 3 (7 days old) was sacrificed 4 months after the feeding of eggs. About 700 of cysticerci were found. Again all the cysticerci were found on and within the liver (*Fig. 2*) and none in other part of the carcass. The cysticerci were also smaller than those of ordinary *C. bovis*. They measured only 1.5 to 2.3 by 2.0 to 4.2 mm (*Fig. 3*). Out of 700 cysticerci, 164 were found degenerated. The morphological study of the

cysts revealed no differences from the cysts obtained from Calf No. 1. The rudimentary hooklets were seen in 7 out of 100 cysticerci examined.

## DISCUSSION

The 64 specimens examined in this study were morphologically identical to *T. saginata,* except one monster. Though there were slight variations among the specimens, in general they all fell in the range of a typical *T. saginata* described by pioneer workers. Experimental infection of calves with the cysticercus was done in order to secure further evidence to prove their identity with *T. saginata.* Only calves younger than 7 days old were susceptible; a calf of 30 days old was completely resistant to the infection. Besides, the obtained cysticerci were quite different from those of ordinary *C. bovis* in size, site of parasitation, and development. The results indicated that cattle seemed not to be the proper intermediate hosts of *T. saginata* in Taiwan. The complete resistance of cattle to infection by the worm in this island was also reported by Yokogawa in 1934 (5). The parasites of the same species sometimes utilize different intermediate hosts in different areas. For example, *Schistosoma mansoni* of Puerto Rico strain does not infect *Biomphalaria alexandria*—the natural snail host of *S. mansoni* in Egypt (10). Consequently, the failure of infection by the worm only proves that cattle are not the natural intermediate hosts for the worms in Taiwan. The aborigines in this island, as stated previously, have only a limited chance to eat the beef. The author had investigated 60 cases of taeniasis in Wulai district; 28 denied having eaten any beef. On the contrary, the flesh of wild games is frequently taken. Moreover, they prefer to eat the flesh and the internal organs of these wild animals raw. These habits make the author to believe that one or more of the wild herbivorous animals may act as the natural intermediate host of *T. saginata* in this island.

Buffalos, giraffes, llamas and goats have been reported elsewhere as the natural intermediate hosts of *T. saginata.* There are no buffalos, giraffes, nor llamas in the mountains of Taiwan, but some allied wild herbivorous animals, such as mounti-jacks, deer, serows, and omnivorous wild boars are abundant. These wild animals are frequently captured and eaten raw by aborigines.

In nature, the wild herbivorous animals are timid and rarely come close to the fields polluted by human excreta. Birds, however, may play an important role. Actively moving white segments of the worm in human feces might attract the attention of some carnivorous birds and be eaten by them. The birds then disseminate the eggs of *T. saginata* with their stools every where, and the grasses or plants in the deep mountain may, in this way, be contaminated. Thus, the wild herbivorous animals become infected by eating these grasses. This might be the chain of the life cycle of *T. saginata* in Taiwan. The author by chance has observed the crows and blue pies picking up the segments of the worm from human excreta. As indicated by Isobe (1922) the eggs of *T. saginata* are strongly resistant to various environments (6), and also as reported by Penfold *et al.* (1937) are capable of remaining unchanged and viable when passing through the alimentary tracts of birds (11). What kind of herbivorous animals may serve as the intermediate host is the subject of the author's next investigation.

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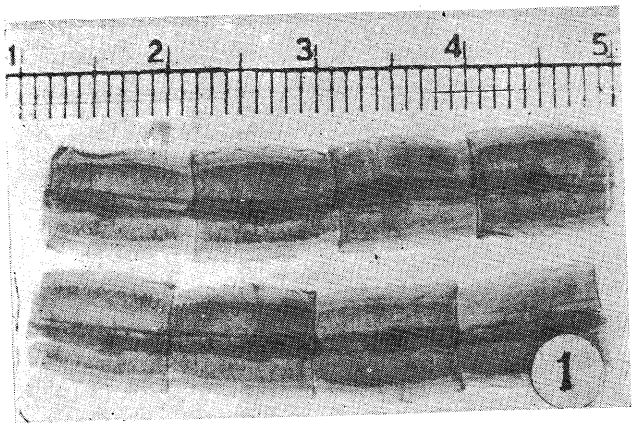
## LEGEND OF FIGURES

*Fig. 1.* Abnormal *Taenia saginata:* complete fusion of the two worms at their lateral margins.
*Fig. 2.* Liver of Calf No. 3, parasitized with numerous small cysticerci.
*Fig. 3.* Cysticercus from the liver of an experimentally infected calf.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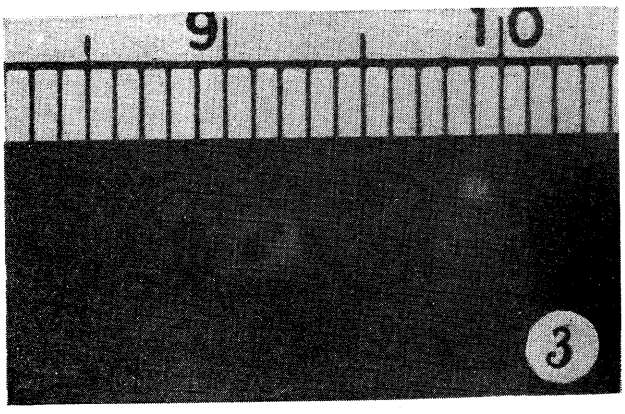
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