THE EFFECT OF MUTILATION ON THE TAPEWORM TAENIA TAENIAEFORMIS

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The reader is undoubtedly aware of work which has been done by Child (1910) and others in mutilating certain free-living species of Platyhelminthes. The present report is concerned with the results of experiments which were designed to test the effect of mutilations on a tapeworm. Since the work was started, and while it was in progress, Beaver (1937) has reported the effects of mutilating the fluke *Echinostoma revolutum*. However, as far as we know, there has been no other attempt to test the effect of similar mutilations on the parasitic members of the phylum.

Various types of abnormalities are known to occur in both tapeworms and flukes. In the Cestoda, the polyradiate condition of the body, the abnormal size and peculiar placement of certain prolgottids (i. e., intercalary or supernumerary proglottids) and the condition known as "forked-strobila" are some of the abnormalities which have been reported. In the Trematoda, the reduction or loss of structures, the reversal of organs within members of a species, and the split-body condition are also known to occur.

It is conceivable that some of these abnormalities might be caused by the mutilating effect of the teeth of a host at a time when the latter acquires the parasite. Some types of abnormality occur rarely. This rarity of occurrence is just what one would expect on the basis of chance, since the probability of a tooth penetrating anything as small as a cysticercus is not very great. Moreover, the chance is even more remote that such a tooth would penetrate the right region of a cysticercus, and that such a penetration would only mutilate and still not be great enough to cause the death of the parasite. Again, from observing the feeding habits of some animals, for example a dog, one would not expect the food to be chewed finely. The chance of such an animal biting into a parasite is practically nil, since the food generally does not remain in the mouth long enough to be chewed thoroughly. Moreover, the teeth of some potential hosts seem adapted to grind and crush rather than cut. Such an animal as a frog would not use its teeth for much except to grasp its food during the process of swallowing. However, it must be admitted that mutilation by natural means is possible and that it probably does occur rarely in Nature.

If such natural mutilations occur, it also is apparent that at such times the parasite passes through a critical period in its life cycle. This may result in its death. However, if it recovers, it may either be normal to all appearances, with parts completely regenerated, or it may be modified in size, shape, etc,. due to the effect of the mutilation.

EXPERIMENTS WITH TAPEWORM MUTILATION

The tapeworm which was selected for this series of experiments was the cat tapeworm, *Taenia taeniaeformis* Batsch, 1786. This species was chosen because the bladderworm stage could be easily obtained in numbers from rat hosts, and also because it was large enough to make the necessary mutilation without difficulty.

A number of laboratory rats were heavily infected with the bladderworm stage by feeding them eggs of an adult tapeworm. The bladderworms were allowed to grow in the rats for nine weeks, after which the stages were of sufficient size, with the characteristic chain of proglottids.

It seemed logical to expect any disturbance of the neck of the tapeworm scolex to affect the strobila, since the chain of proglottids of a tapeworm is the result of

transverse budding of the neck region over a period of time. The only part of the scolex mutilated in this series of experiments was the neck region. Since the tapeworm *Taenia taeniaeformis* does not possess a true neck, this term is used here to indicate that region posterior to the suckers from which the proglottids are formed.

In order to accomplish mutilation of the neck without injury to other parts of the head, it was necessary to exert enough pressure on the bladderworm scolex to cause it to evert. This was accomplished by pressing on it with some blunt instrument. Mutilation always consisted in making a dorso-ventral incision through the worm by means of a safety razor blade or a hot platinum wire; thus bisecting the neck. (Fig. 1). This was accomplished under the medium magnification of a stereoscopic type of binocular microscope, and was done just before the stage was to be fed to the cat host.
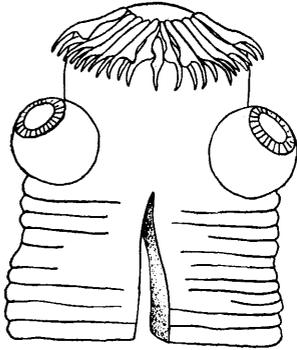

Fig. 1.

Bisection of neck region prior to infection.

Since the cysticercus of *Taenia taeniaeformis* is a proliferating bladderworm, it was necessary to either remove the chain of proglottids prior to bisecting the neck or to bisect both the appended strobila and the neck up to the base of the suckers. When the latter method was employed, the bisection of the strobila started generally at the side of the chain of proglottids. This resulted in a mutilated neck with two strobilae appended to it, one being longer than the other. This difference in size of the two strobilae was hard to avoid, since the movements of a living tapeworm was not conducive to perfect bisection. The effects of such a mutilation are emphasized in the final results obtained for two of the specimens.

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All of the cats used in the experiments were raised from kittens, and were about three-fourths grown at the time they received the parasites. None were infected prior to the time that they were experimentally fed, since each had been segregated in a cage, and had been kept on a controlled diet. Fecal examinations of the hosts from time to time prior to the experimental feeding showed them to be without the tapeworm. Control animals were also kept, none of which were parasitized when examined at autopsy.

Each cat was kept without food for 24 hours prior to the time of feeding it the mutilated bladderworms. The stages were placed in deep pockets cut in beef liver or were wrapped up in small pellets of hamburger. The cats took such food without chewing it, and therefore the mutilation was assured of entrance into the alimentary canal of the host without being altered in any way.

For convenience, the experiments will be grouped under two headings:

A. Those in which the chain of proglottids was removed from the strobilocercus, so that only the neck region of the scolex was mutilated.

B. Those in which the chain of proglottids was left intact, the mutilation extending through the proglottids as well as the neck of the scolex.

GROUP A

Experiment 1. Four bladderworms were used in the experiment. The chain of proglottids was removed from each, and the neck of the scolex was split longitudinally. The cut, which was made by a razor blade, extended dorso-ventrally and divided the neck region into right and left halves. All four bladderworms were fed to one cat host.

The cat was killed and examined 12 days after the experimental feeding. Two normal tapeworms were recovered from the small intestine. These worms possessed
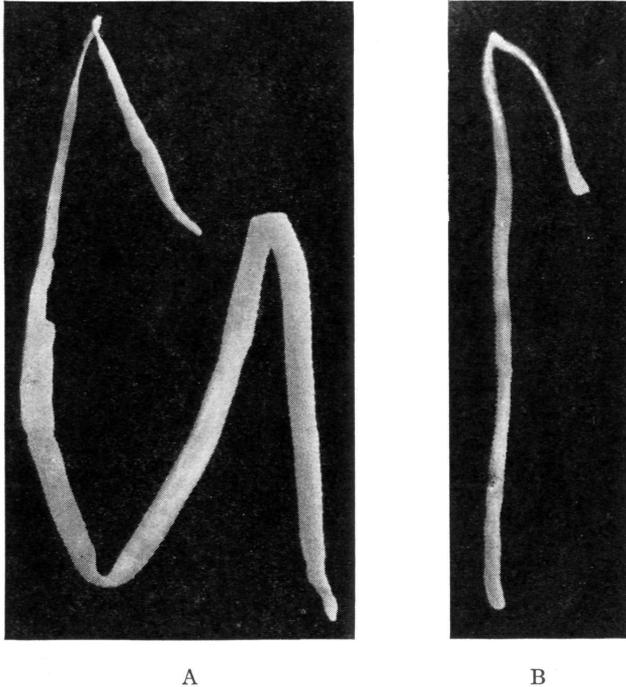

A   B

Fig. 2. Forked strobila: a, 12 days after infection; b, 12 days after infection.

short strobilae, probably due to the fact that they were without strobilae at the time they were fed to the cat. Mutilation in this experiment failed to produce abnormal individuals, regeneration being apparently complete. There was a 50 per cent mortality to the worms in the experiment.

Experiment 2. Four bladderworms were again used in this experiment, and again the chain of proglottids was removed from each. The neck region was split dorso-ventrally into right and left halves by means of a hot razor blade. All four bladderworms were fed to one cat host.

The cat was killed and examined 14 days after the experimental feeding. Two normal tapeworms were recovered. As in the former experiment, these worms possessed only short strobilae. Again, regeneration was apparently complete. There was a 50 per cent mortality to the worms in the experiment.

GROUP B

Experiment 1. Four bladderworms were used in the experiment. The strobila and the neck of each were partially divided dorso-ventrally by means of a hot

platinum wire. The mutilation did not divide the body completely since it extended for only a short distance through the parenchyma from one surface. All four bladderworms were fed to one cat host.

The cat was killed and examined 14 days after the experimental feeding. Only one tapeworm was recovered. This specimen possessed longitudinal indentations which extended the length of the body. However, it appeared normal in all other respects, the only approach to abnormality being the longitudinal striations of the body. There was a 75 per cent mortality to the worms in this experiment.

Experiment 2. Four bladderworms were used in the experiment. The strobila and neck of each were split dorso-ventrally into right and left portions by means of a razor blade. The cut extended anteriorly through the neck to the base of the suckers. All four bladderworms were fed to one cat host.

The cat was killed and examined 12 days after the experimental feeding. One tapeworm was recovered from the small intestine. This specimen was abnormal in that it possessed a forked strobila. (Fig. 2, a). The two strobila started at the neck region, which was also divided, there being no indication of regeneration. It was impossible to determine whether in time the two necks would have grafted together forming one or whether the division would have continued, always forming two strobilae. However, the two necks seemed to be completely healed, which, probably, would have prevented their growing together to form a single neck again. Moreover, since periods of 12 and 14 days from infection were sufficient lengths of time to obtain complete regeneration in the necks of the tapeworms described in Group A, it seems reasonable to expect it to have occurred in the tapeworms of this experiment. The failure to get even a partial regeneration within these time limits suggests that regeneration probably would not have occurred had the tapeworm remained with the host.

There was a 75 per cent mortality to the bladderworms in this experiment.

Experiment 3. Four bladderworms were used in the experiment. Again, the strobila and neck of each were split dorso-ventrally into right and left portions. The division was made with a hot razor blade, and extended anteriorly through the neck to the base of the suckers. All four bladderworms were fed to one cat host.

The cat was killed and examined 12 days after the experimental feeding. One tapeworm was recovered from the small intestine. This specimen was abnormal in that it possessed a forked strobila. (Fig. 2, b). As in the preceding experiment, the proglottids of each strobila had assumed the general shape of normal proglottids, and there was no indication of healing in the neck region. There was a 75 per cent mortality to the bladderworms in this experiment.

AN EXPLANATION OF THE ABNORMALITY KNOWN AS FORKED-STROBILA

There have been a number of cases of forked-strobila of tapeworms reported. The recorded cases up to 1900 have been summarized by Braun (1894–1900).

The abnormal tapeworms recovered in this series of experiments were forked immediately behind the base of the suckers. Examination showed that the scolex, with the exception of the neck region, was normal both in size and structure. The proglottids in the strobilae of both worms had assumed the shape of normal proglottids. These two abnormal tapeworms are somewhat similar, externally, to the case of forked-strobila reported by Chandler (1930) for *Taenia pisiformis* recovered from a dog. Their internal anatomy has not been studied.

The results of the present investigation suggest an explanation for the abnormality known as forked-strobila. It is not suggested that this explanation is necessarily correct for all cases of forked-strobila found in Nature. However, since the condition can be artificially produced by dividing the neck region of the bladderworm scolex, it seems possible that it might occasionally be produced by the teeth of a host animal at the time the latter acquires its infection.

CONCLUSIONS

1. The cyst covering of the bladderworm of *Taenia taeniaeformis* is not necessary for successful infection of the definitive host, since bladderworms which have had the cysts removed produce adult worms when fed to the cat.

2. The strobila of the bladderworm of *Taenia taeniaeformis* is not necessary for successful infection of the definitive host, since bladderworms which have had the strobilae removed produce adult worms when fed to the cat.

3. Mutilation of the neck and strobila of the bladderworm of *Taenia taeniaeformis* does not necessarily kill this tapeworm, since cats become infected after ingesting the mutilated bladderworms.

4. The abnormality known as forked-strobila can be produced experimentally in *Taenia taeniaeformis* by dividing the neck and strobila of the bladderworm longitudinally into right and left portions before feeding the stage to the cat host.

5. Mutilating the neck of the bladderworm of *Taenia taeniaeformis* by dividing it longitudinally does not necessarily produce an abnormal tapeworm, since complete regeneration may occur.

6. The production in *Taenia taeniaeformis* of the condition known as forked-strobila by artificial mutilation of the scolex and strobila of the bladderworm suggests that this abnormality may be produced naturally by the teeth of the definitive host at the time the latter acquires its infection.

7. It seems logical to conclude that similar mutilations to other species of tapeworms might produce the condition known as forked-strobila, in as much as this abnormality is known to occur naturally in other species. It also seems logical to expect in some cases a complete regeneration of the mutilated area, resulting in the production of a normal tapeworm.

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