

The Source of *Bothriocephalus latus* in Japan.

by

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Bothriocephalus latus, which was formerly thought to be restricted to Europe in its distribution, is the commonest tape-worm found in Japan. It is met with everywhere in the country, of course with local differences as to its frequency. The identity of the species with the European form admits in my opinion of no doubt. I would not have made this remark, had not Küchenmeister of late erroneously assumed that in Europe more than one species is included under the name of *B. latus*.

As far as my experiences go, *Tænia mediocanellata* occurs in Japan much more rarely than *B. latus*; among dozens of tape-worms that I have examined, only a single specimen of the former species was found. That fish, the recognized source of *Bothriocephalus*, is used as food much more generally in Japan than beef (the source of *Tænia mediocanellata*), sufficiently explains the above-stated fact. *Tænia solium*, if ever it occurs in Japan, must be exceedingly rare. I have indeed, never as yet met with it in Tōkyō. This is undoubtedly due to the fact that pork as an article of food is even less used than beef. Unfortunately means are not yet at my disposal for determining the occurrence of human tape-worms at any locality on statistical grounds.

As is well known, Prof. M. Braun¹⁾ was the first to show that in the Baltic region (Dorpat) the plerocercoid larvæ of *B. latus* infest the viscera as well as the flesh of the pike (*Esox lucius*) and of the burbot (*Lota vulgaris*). He proved that the above-mentioned tape-worm, so common in Dorpat and vicinity, is derived from using these infected fishes, and the pike especially, as food. Küchenmeister²⁾ alone stood out against considering the pike as the intermediate host of *B. latus*, substituting certain Salmonidæ (*Salmo salar*) in its stead. His opinion has however suffered a well-grounded refutation by Braun and Leuckart,³⁾ so that the former's discovery stands as an established fact. According to Leuckart, Grassi in Catania also succeeded in raising *B. latus* in himself from larvæ taken from the pike. And Parona⁴⁾ in Lombardy found larvæ, which were experimentally proved to belong to *B. latus*, not only in the pike but also in the perch (*Perca fluviatilis*). Further it turned out from Zschokke's and my observations that some Salmonidæ are also to be counted among the intermediate hosts of *B. latus*.

Zschokke's researches⁵⁾ at Geneva, one of the places noted for the occurrence of *B. latus*, have proved that there its principal source is *Lota vulgaris* and after it *Perca fluviatilis*, while infection from pike and salmon is considered as occurring only in exceptional cases. Of the latter, *Salmo umbla* was found almost regularly infested by *Bothriocephalus*-larvæ.

1) Zur Entwicklungsgeschichte des breiten Bandwurmes. Würzburg 1833.

2) "Wie steckt sich der Mensch mit *Bothriocephalus* an?" Berlin. klin. Wochenschrift. Nr. 32, 33. 1885.—"Die Finne des *Bothriocephalus* und ihre Uebertragung auf den Menschen." Leipzig 1886.—"Weitere Bestätigung meiner Behauptung, dass die Finne des Hechtes nichts mit *Both. latus* zu thun hat." Deutsche medic. Wochenschrift. Nr. 32. 1886.

3) See Leuckart "Zur *Bothriocephalus*-Frage." Centralbl. f. Bacteriologie u. Parasitenkunde. Nr. 1, 2. 1887.

4) In "Estratto dei Rendiconti del R. Istituto Lombardo. Ser. II. Vol. 19. 1886.

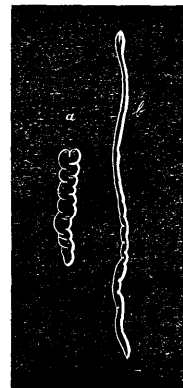
5) "Der *Both. latus* in Genf." Centralbl. f. Bact. u. Parasitenk. Nr. 13, 14. 1887.

From what has been said it is apparent that the (last) intermediate host of *B. latus* includes several species of fish which may belong to different families and that the principal source of that tapeworm may vary according to localities.

In Japan, where as already said, *B. latus* is abundant, none of the above-mentioned fishes are known to occur, although the pike is said to exist in Saghalien. What fish is then the source of *B. latus* in Japan?

There has been among the Japanese a popular belief that tapeworms develop from eating certain fishes. *Onchorhynchus Perryi* Hilgd. (*Masu*) and *Onchorhynchus Haberi* Hilgd. (*Sake*) were the most suspected, a belief which was certainly without any scientific basis. Guided by this suspicion, however, I examined in May 1886 a specimen of *Onchorhynchus Perryi*, and was not disappointed. Seven *Bothriocephalus*-larvæ, unmistakable by the configuration of their head, were found imbedded in the trunk-muscles. In form, size and motions, they corresponded exactly with Braun's description and figures of the larva of *B. latus*.

Concerning the appearance of the larvæ I have nothing of importance to add to what is already known. Nevertheless a few words about them might be useful, since zoological literature is not accessible to many in Japan. The larva of *B. latus* is a slender elongated worm of white color. The body is properly speaking not flat but rather thick. Its length varies from 8 to 30 mm, its breadth from 1 to 3 mm. When contracted, the length is reduced by more than one-half, but the breadth relatively increases so that it acquires a thick wrinkled form. The head is then involuted and shows a cleft-like depression at the end. If such a larva be put into



Larvæ of *Bothriocephalus latus* from *Onchorhynchus Perryi*. *a*, in contracted; *b*, in extended state. About 2 × magnified.

luke-warm water or salt-solution, it begins to move energetically. The head is alternately thrown in and out, the body at the same time bending and stretching and exhibiting also peristaltic motions which travel from end to end. The head, when extended, is club-shaped, hardly 1 mm in length and bears two shallow longitudinal grooves, thus essentially agreeing in form with the head of the fully grown *Bothriocephalus latus*. The body is solid as in the mature worm but without any trace of strobilization or of sexual organs. Examined under the microscope, it clearly shows some of the excretory vessels and calcareous bodies, of which there are comparatively many. The larva, as it lies in the flesh, is tolerably extended but with the head always drawn in. It rarely lies straight but usually irregularly coiled. No sort of capsular membrane invests it. Within the body of the host, it by no means makes such active movements as described above; but it is exceedingly probable that it may at any time shift its position within the host. At least, there can be no doubt about this much, that the larvæ found in various parts of fishes have wandered in from the intestinal canal. Braun found them not only in the muscles of the pike, but also in the various organs of its body-cavity, some hanging on the intestinal wall, others free in that cavity. Moreover he found on the liver-surface tracks of their wanderings. In *Onchorhynchus Perryi*, I have as yet never found them in any other place than in the trunk-muscles.

To prove that the *Bothriocephalus* larvæ obtained from *Onchorhynchus Perryi* belonged to *B. latus*, it was necessary to experiment with them. So I swallowed two larvæ, one of which was however injured and my assistant, Mr. M. Kikuchi, kindly offered his services and swallowed three. This was done on May 10th 1886.

From the 2nd or the 3rd day, I began to experience now and then slight pains in the duodenal region. This lasted for some days and

then entirely stopped, so that I felt myself in my usual health until the 28th of the same month, when slight diarrhœa began to inconvenience me. On June 1st a piece of *B. latus*, 22.5 cm long, was discharged. Since it had the characteristic terminal proglottis, it was certain that no segments had been previously lost. On the following day, viz. 22 days after the beginning of the experiment, the remainder of the tape-worm body including the head was obtained by means of anthelmintic. It seemed that only one (probably the uninjured) of the two larvæ swallowed had developed into the tape-worm.

In Mr. Kikuchi's case, intestinal complaint commenced a little later than in mine. In both cases, fœces were subjected to microscopical examination from time to time, but *Bothriocephalus*-eggs were never met with. It seems that it requires a considerable length of time before the worm is ripe enough to let some of its eggs escape from the uterine opening. On June 27th anthelmintic was given to Mr. Kikuchi. Unfortunately however no worm was obtained. Apparently it became lost, proper precautions not having been taken to secure it. After this his complaint entirely ceased.

The total length of the worm that had grown in me was 315 cm (over ten feet!) and the number of proglottides, as far as could be counted, 1467. Of these the last 617 had their uterus already filled with eggs. Considering that a larva of insignificant size had acquired the above-stated respectable dimension during a period of only 22 days, the rate of growth is really wonderful and one might doubt the genetic connection between the larva voluntarily swallowed and the tape-worm produced, were it not for the similar results arrived at by Braun and Zschokke. The former experimented not only on cats and dogs but also on three of his students, who had voluntarily offered themselves for the purpose. They were first ascertained to have no tape-worm in the body and then each swallowed 3 or 4

larvæ. Symptoms appeared in 3 weeks and in a month every one of them began to discharge *Bothriocephalus* eggs. At this, anthelmintic was given and in all more than 6 specimens of *B. latus* were obtained, averaging about 335 cm in length. Zschokke also obtained positive results in several experiments on man. In 4 cases symptoms appeared in 16–22 days after swallowing the larvæ and the tape-worms obtained in 20–26 days measured about 129 cm on an average.

Some specimens of *Bothriocephalus*-larvæ from *Onchorhynchus Perryi* were sent to Prof. Leuckart for examination. He did not hesitate to pronounce them as identical with those found in the pike of Europe.

Thus, the fact is established that *Onchorhynchus Perryi* does harbour the larva of *B. latus*; and I believe I am right in claiming that fish to be at least one of the chief sources of *B. latus* in Japan. Subsequently I have had occasion to examine 7 examples of that fish at different periods of the year and found *Bothriocephalus*-larvæ in all but one. The single negative case was a young *O. Perryi* from the Hokkaidō. It was in a state of putrefaction, making the task of search so unpleasant, that a thorough examination was abandoned. Another Hokkaidō specimen, said to have been sent in ice contained at least 4 larvæ. The other specimens were brought to the Tōkyō market from neighboring districts, probably from the Tonegawa. The number of larvæ lodged in one fish was not large, 7 having been the maximum. In one case, only a single larva could be found after a laborious search. Even then it would be unsafe to assert that no chance was left for some to escape unnoticed. At all events, the number of the *B. larvæ* in *O. Perryi* is much less than that found by Braun or Zschokke in the pike, burbot, etc. But to judge from my somewhat limited experience, their occurrence in *O. Perryi* seems to

be tolerably constant. Another reason for regarding *O. Perryi* as at least one of the chief sources of *B. latus*, is the undeniable fact that where that fish abounds, the tape-worm is also abundant. Toyama in the province of Echū is such a place. In Yezo, especially among the Ainos, tape-worms are said to be common. Considering that *O. Perryi* occurs there in plenty, these tape-worms presumably belong to the species *Bothriocephalus latus*.

O. Perryi is in some parts of Japan often eaten raw (*Sashimi*) like many other fishes. Under such circumstances, infection with *Bothriocephalus* is highly probable and all the more so since its larvæ in the flesh might easily be mistaken for a piece of fat, tendon or nerve. Once a friend told me, soon after his return from a short visit to Saikyō, that he had there tried the "*sashimi*" of the fish in question. I warned him of what change might perhaps occur in his health within 3 weeks' time, little suspecting that he would, as he really did, present me with a fine specimen of *B. latus* at the end of a month. In Tōkyō, where *O. Perryi* is altogether scarce, its "*sashimi*" is not generally indulged in, a fact which probably explains the comparative scarcity of *B. latus* in this city.

The life-tenacity of *Bothriocephalus*-larvæ seems to be of no small degree. They may retain vitality for a week outside their host and Braun even found them alive not only in weakly salted pike but also in such that had been frozen. It is however certain that the heat of thorough cooking or roasting suffices to render them harmless. At the same time it must be admitted that ordinary methods of cooking do not exclude all chances of infection, as is clear from the way we obtain our *Tænia* from beef or pork. A naturalist friend in Tōkyō once discharged a *B. latus*, which he is inclined to regard as having been received from the flesh of *O. Perryi*, which he had eaten *roasted* about one month previously. The fish had been

sent from Yezo preserved in *Sake-dreg* (*Kasu*). A few other enquiries were made of persons who had been tape-worm patients and many of them recollected having eaten *O. Perryi* in some form or other.

To all appearances then *O. Perryi* is the chief source of *B. latus*. I do not wish however to emphasize this too strongly, since my examination of other river-fishes is still very incomplete.

Onchorhynchus Haberi, another species of salmon common in Japan, closely resembling *O. Perryi* in habits and other respects, is peculiarly open to suspicion. Nevertheless, three specimens of this fish, obtained in the Tōkyō market and carefully searched by Mr. Kikuchi and myself, showed no trace of *Bothriocephalus-larvæ*. *Carassius auratus* (*Funa*), *Cyprinus carpio* (*Koi*), *Plecoglossus altivelis* (*Ayu*) and a species of *Salmo* (*Yamabe*) were also searched but with negative results. However the number of individuals examined was, as in the case of *Onchorhynchus Haberi*, too small to allow of much weight being attached to the conclusions. A more complete investigation of our fresh-water fishes is very much to be desired.

