3.2.11 Bothriocephalosis

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A. Name of Disease and Etiological Agent

Bothriocephalosis is the intestinal infection of certain fish by the cestode *Bothriocephalus acheilognathi* (Yamaguti 1934), a Pseudophyllidean tapeworm. The infecting organism is also known as the Asian fish tapeworm and as the Chinese tapeworm and has had several synonymous scientific names, including: *Bothriocephalus opsariichthydis = Bothriocephalus opsalichthydis*, *Bothriocephalus fluviatilis*, *Schyzocotyle fluviatilis*, *Bothriocephalus gowkongensis*, and *Bothriocephalus phoxini*.

B. Known Geographical Range and Host Species of the Disease

1. Geographical Range

The Asian tapeworm has been reported in Asia, Australia, Europe, South Africa, and North America. In North America, it has been reported in Mexico, British Columbia, throughout the lower half of the United States, and in Colorado, Nebraska, New Hampshire, New York, Nevada, and Utah.

2. Host Species

Most members of the family *Cyprinidae* should be considered as potential hosts. However, goldfish *Carassius auratus*, are apparently not susceptible to *B. acheilognathi*. This worm also infects some silurids, poecilids, percids, and centrarchids. In the United States, the fish host species include: goby *Awaous guamensis*, grass carp *Ctenopharygodon idella*, common carp *Cyprinus carpio*, sleeper *Eleotris sandwicensis*, plains killifish *Fundulus zebrinus*, mosquito fish *Gambusia affinis*, humpback chub *Gila cypha*, roundtail chub *Gila robust*, green sunfish, *Lepomis cyanellus*, virgin spinedace *Lepidomeda mollispinis*, peamouth *Mylocheilus oregonensis*, golden shiner *Notemigonus crysoleucas*, emerald shiner *Notropis atherinoides*, red shiner *Notemigonus lutrensis*, spotfin shiner *Notropis spilopterus*, fathead minnow *Pimephales promelas*, woundfin *Plagopterus argentissimus*, guppy *Poecilia reticulata*, Colorado pikeminnow *Ptychocheilus lucius*, speckled dace *Rhinichthys osculus*, and green swordtail *Xiphophorus helleri*.

C. Epizootiology

Acute infection with the Asian tapeworm occurs when intensively cultured larval fish feed on copepods infested with high levels of *Bothriocephalus acheilognathi* procercoids. Up to 80% mortality among larval fish has been reported by fish producers; however, death as a direct result of tapeworm infection is not a common occurrence. In the United States, most problems associated with this worm involve reduced growth and the inability of infected fish to withstand harvesting procedures. The worm evidently shortens the life span and stunts the growth of feral fish.

Operculated eggs of the Asian tapeworm are shed with fish feces into the water. A motile coracidium emerges from these eggs and is eaten by cyclopoid copepods. Larval worm development proceeds within the copepod. Copepods are eaten by fish and the developing worm is released in the anterior portion of the alimentary canal. The worm attaches to the mucosal lining of the intestine and matures producing gravid segments which release eggs. Worms up to 60 cm have been reported; however, most mature worms measure between 5 to 8 cm.

The Asian tapeworm is a thermophile that prefers temperatures of 20 to 30^{o}C. Growth and maturation are fastest at temperatures above 25^{o}C. However, in small fish the density of the worms decreases at these temperatures probably because of limited space and nutrient availability. Egg maturation, hatching, and coracidium movement are maximized at 25 to 30^{o}C. Spring to late summer is the peak recruitment period because most worms are gravid at this time.

D. Disease Signs

1. **Behavioral Changes Associated with the Disease**
   Occasionally, fry hang listlessly around the edge of the pond.

2. **External Gross Signs**
   Heavily infected golden shiners appear emaciated with a swelling in the anterior portion of the abdomen. Weakened fish often develop bacterial problems resulting in signs typical of columnaris disease or motile aeromonas septicemia in grass carp (20 to 30 cm in length). Bloating and raised scales may also occur with massive tapeworm infections.

3. **Internal Gross Signs**
   The intestinal tract just posterior to the first bend is greatly enlarged and appears yellow to white from the massive worm infection. The intestines become stretched, thin, flaccid and may rupture. In 20 to 30 cm fish, the body cavity may be filled with a cloudy yellow fluid. Death is due to physical blockage of the intestine by the worms or to intestinal rupture.

   No signs are apparent when *Bothriocephalus acheilognathi* infections are light.

4. **Histopathological and EM Observed Changes Associated with the Disease**
   The attachment of the scolex to the intestine results in mechanical damage, localized hemorrhages, inflammation, and focal pressure necrosis of the mucosa. More severe damage including loss of microvilli and enterocytes has been reported. Lymphocytes, macrophages, and eosinophils accumulated in the wall of the infected gut and migrated into the lumen where they adhered to the parasite tegument.

E. Disease Diagnostic Procedures

1. Presumptive Diagnosis

Asian tapeworms are in the anterior section of the intestinal tract, just posterior to the first bend. The scolex (head) of the tapeworm assumes a pit viper or arrowhead shape during a cycle of extension and contraction. For an example, see the movie showing Bothriocephalus under various lighting conditions. The shape of the scolex is difficult to determine if the worm is dead, frozen, or preserved. Histological or clinical signs that are useful to the diagnosis of infected fish have not been demonstrated.

2. Confirmatory Diagnosis

Once tapeworms with pyramidal scolices are found, they must be distinguished from all others with similar shaped scolices. Some worms of the genera *Anoncocephalus*, *Atractolytocestus*, *Bathybothrium*, *Echinophallus*, *Eubothrioides*, *Eubothrium*, *Fistulicola*, *Glaridacris*, *Marsipometra*, *Proteocephalus*, *Ptychobothrium*, and *Schistocephalus* species have a pit viper or pyramid-shaped scolex. To aid in the differentiation of these tapeworms, the following definition and key for *Bothriochephalosis acheilognathi* is given.

Bothriocephalus acheilognathi is a complete and distinctly segmented, thin tapeworm that can reach a length of over 50 cm, but is usually less than l0 cm. Segmentation is evident on worms l mm or more in length. *Atractolytocestus*, *Glaridacris*, and *Ptychobothrium* species are not segmented.

Bothriocephalus acheilognathi has a flattened scolex with two bothria (deep, elongated sucking grooves dorsal and ventral as seen in Figure l), no hooks, no spines, no suckers (sucking devices surrounded by a muscular fringe are usually circular as seen in Figure 1), and no proboscides (short tentacles). In the lateral view (normal viewing position of the worm), the scolex takes a strong pit viper or arrowhead appearance when extended and a balled or fist-shaped appearance when contracted. The posterior portion of the scolex is wider than the first few segments in both the extended and contracted positions. *Schistocephalus* species have scolices less than the width of the first few segments.

Bothriocephalus acheilognathi has no neck. The neck, which is present and very obvious on *Marsipometra* species and sometimes present on *Eubothrium* species, is a nonsegmented area posterior to the scolex, anterior to the first obvious segment, and two or more times the length of the anterior segments (see Figure 1).

Bothriocephalus acheilognathi has no dorsal or ventral median furrow. This furrow, present in *Eubothrium* and *Bathybothrium* spp., is not always clearly visible for the full length of the worm, but careful viewing reveals definite short sections of the furrow. The furrow may appear as a small indentation on the posterior edge of several proglottids (see Figure 1).

F. Procedures for Detecting Subclinical Infections

Sample size should be adequate to detect the presence of infected fish at a 5% level of prevalence (see Section 1, 3.1.1 General Procedures for Parasitology).

1. Sever the head of the fish just behind the opercular flap.

2. The tip of blunt scissors can then be inserted into the body cavity and the ventral wall cut to the anus without severing the intestine.

3. Cut the intestinal tract at the anus and at the esophagus or just posterior to the stomach and remove the intestine with the fingers or forceps.

If large worms are present, they will be apparent as a yellow to white bulge in the intestine. Large worms can be seen with the naked eye; however, a microscopic examination is required to detect small worms. If none are obvious, the intestine should be uncoiled and the attached tissues removed; this can usually be done by rubbing the intestine gently between the fingers. However, if the intestinal tract is small and thus easily damaged, it can be placed directly on a microscope slide or glass plate (9 x 9 x 0.3 cm) without removal of attached material. The uncoiled intestinal tracts from several small fish can be placed side by side on a glass plate. An uncoiled intestine can be folded if it is longer than the plate. A second slide or glass plate placed over the excised intestine spreads the intestine for easy visibility. Usually, the two slides or glass plates are pressed together with two or four small binder clips placed on opposite sides. Small specimens less than 3 cm long may not require binder clips for flattening.

Parasites can be detected in the intestine with a 15 to 30-power dissecting microscope and reflected light. The scan objective (2 to 4 X magnification) on a binocular microscope can be used if the specimen is small enough to be placed between two slides. Once an investigator has learned to recognize small intestinal worms (350 μm minimum length), the technique can be used rapidly and with confidence. Asian tapeworms sometimes take on a silvery cast and movement will be detected if the specimen is viewed for 15 seconds. Because these tapeworms occupy the anterior part of the intestinal tract, this portion should be examined thoroughly. This technique can be used for fish up to 20 cm long, but it is most effective for fish less than 13 cm. For fish longer than 20 cm, the anterior third of the intestine can be removed and slit open lengthwise, and the contents can be scraped out with a scalpel. The contents can then be spread and flattened between two glass plates (no binder clips are necessary) and examined microscopically. Because food particles may obscure worms, best results can be obtained with fish that have not eaten for at least 24 hours.

G. Procedures for Determining Prior Exposure to the Etiological Agent

None available.

H. Procedures for Transportation and Storage of Samples to Ensure Maximum Viability and Survival or Recognition of the Etiological Agent

Submitting live fish is best; if this is not possible, carefully remove the tapeworms, keeping the scolex intact, and place them in 80^{o}C water for about five minutes and then transfer to 10% formalin. Confirmatory diagnosis is unlikely from preserved specimens.

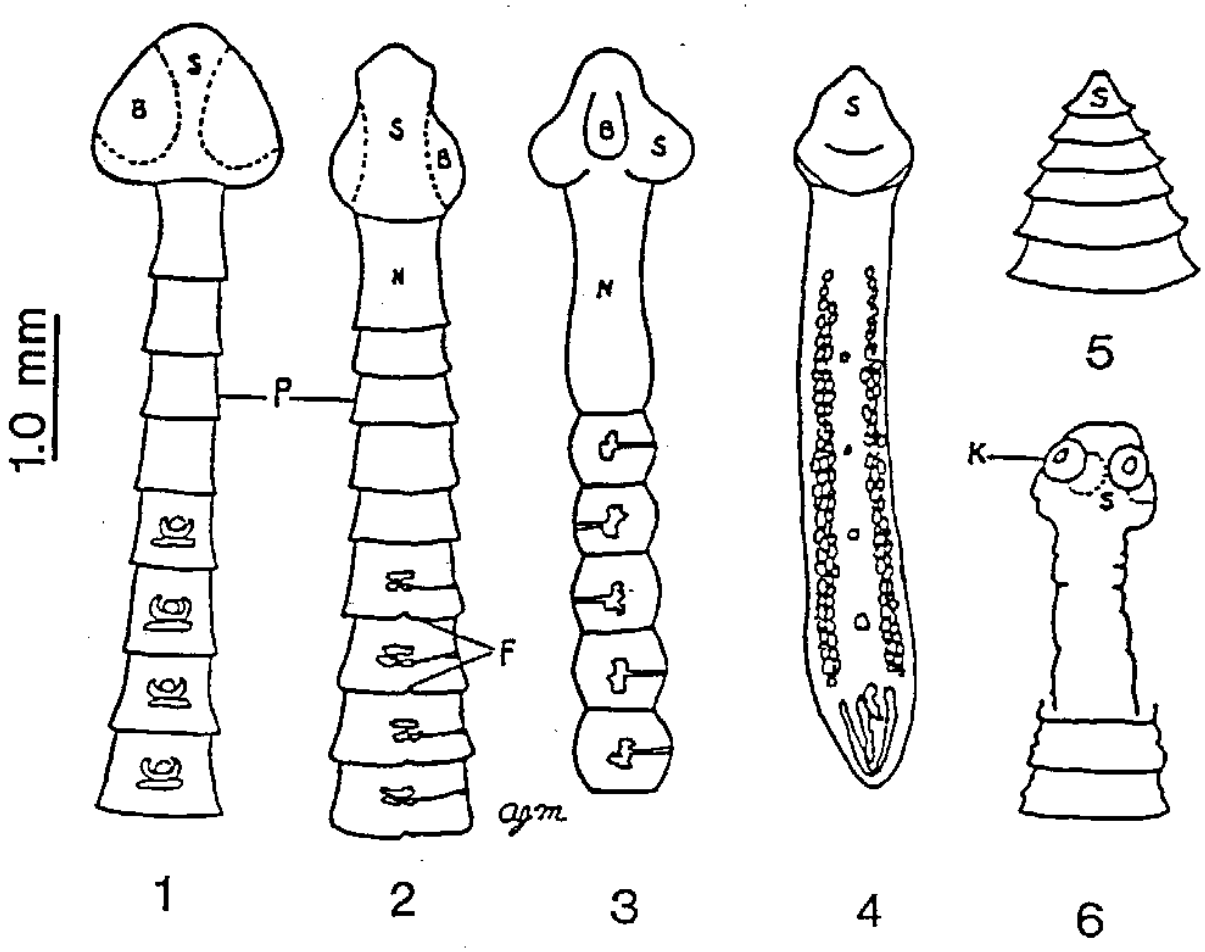

Figure 1. (1) *Bothriocephalus acheilognathi*; (2) *Eubothrium salvelini*; (3) *Marsipometra parva*; (4) *Glaridacris larvei* (unsegmented); (5) *Schistocephalus solidus*; (6) *Proteocephalus ambloplitis*; B – bothria; F – furrow; K – sucker; N – neck; P – proglottid; S – scolex.

I. Key for the Separation of Adult* Bothriocephalus Acheilognathi From Other Tapeworms with Pyramidal or Arrowhead-shaped Scolices

1a. Non-segmented or segmentation incomplete or indistinct……*Atractolytocestus*
……. *Glaridacris*
……... Ptychobot*hrium*
1b. Segmentation complete and distinct……2
2a. Scolex with 4 or 5 suckers……*Proteocephalus*
2b. Scolex with 2 bothria no suckers…… 3
3a. Tapeworms of marine fish…….. *Anoncocephalus*
……. *Echinophallus*
…….. *Eubothrioides*
……. *Fistulicola*
3b. Tapeworms of freshwater fish……4
4a. Dorsal-ventral median furrow……*Bathybothrium*
…….. *Eubothrium*
4b. No dorsal-ventral median furrow……..... 5
5a. Neck……..... *Marsipometra*
5b. No neck……..... 6
6a. Wide portion of scolex (constricted) is the same or less than the width of the anterior segments……..... *Schistocephalus*
6b. Solex clearly wider than anterior segments……..... *Bothriocephalus acheilognathi*

* Scolex characters are usually found in juvenile worms in fish.

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