Parasitosis of Short-finned eel, *Anguilla australis schmidti*, in Taiwan


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Abstract
In Taiwan, a local fish farm had imported 300 short-finned eels, *Anguilla australis schmidti*, from an unknown country. The infected eels showed anorrhea, poor appetite, lost of activity, and a decreased escape-reaction. In five weeks, about 130 short-finned eels died. The total mortality was above 43% (130/300). The results of necropsy of the eels included petechial hemorrhages on the surface of the stomach serosa and serious atrophy of fat tissue. Simultaneously, adult red worms were discovered in the peritoneal cavity, abdominal wall, organs, and intestinal serosa of those diseased eels. Identification of parasites revealed five different species of parasites: *Anisakis* sp., *Eustrongyloides* sp., *Echinorhynchus gadi*, *Lepidopus caudatus*, and *Brachyphallus crenatus*. This is the first case of multiple internal parasite infection in cultured short-finned eels in Taiwan.

Introduction
There are not many epizootics and mass mortalities due to parasitic infections reported in fish. However, the presence of parasites may cause large losses for the fishing industry. The main reason for the economic loss caused by parasites in fish is the weight loss of the infected individuals, although it may not be associated with mass mortalities (Kabata, 1985a, Kailola et al., 1993, Choudhury et al., 2004). Usually, a prolonged gradual die-off of diseased fish is the main result of parasite infections. Sometimes, even the disease process may go unnoticed.

According to our experience, the absence of quarantine may allow parasites to be imported and cause subsequent economic losses. Particularly, infection with nematodes may cause disease and death. *Acanthocephala* can invade the body through the nose lip, after which they induce an inflammatory reaction in the diseased regions (Kabata, 1985b). The larvae of *Tetrahynchidea* and *Digenea* in muscle or small intestine are also able to have a detrimental effect on the body, whereby they can lower the economic value and health status of the infected fish (Kabata, 1985a). In this case, five different species of parasites were discovered and identified in the imported short-finned eels. The name of the source was not provided by the pond owner. Five different worms were detected in the peritoneal cavity of diseased short-finned eels.

Materials and methods
Fish
Short-finned eels, *Anguilla australis schmidti*, each weighing 600 to 750 g, were imported

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from an unknown country. Most eels were extensively anorrhexic and emaciated. During five weeks, the total mortality of this fish farm was above 43% (130/300).

Isolation of bacteria
Specimens for bacteriology were taken from various organs of diseased fish. All specimens were inoculated onto TSA and blood agar, and incubated at 25°C for 24-48h.

Parasitological examination
Eels were euthanized by MS222 (800 ppm) and necropsied. No parasites were found on the gills and skin of the diseased eels. The infected eel tissues were dissected and the sample was homogenized. 1% pepsin digestion solution (pH < 2) was added. The mixture was incubated at 37°C and stirred for 4 h. The sediment from the solution was collected and washed twice with buffered saline. Finally, the sample was placed in a Petri dish and further studied under a dissection microscope.

Results
Gross finding
Many adult worms were found in the peritoneal cavity, abdominal wall, organs, and intestinal serosa of the ill fish. The fat tissue showed serious atrophy, and numerous petechial hemorrhages on the serosa of the stomach (Figure 1A) were found in infected fish. Tiny light brown nematodes, about 1.5 cm long, were discovered in the abdominal cavity of the diseased eels (Figure 1B). The nematode and their ova were detected in the fish digestive tract, muscle, mesentery, and swim bladder after digestion with the artificial gastric juice. In the abdominal wall of a diseased fish, a red nematode, about 4 cm long, was found (Figure 1C). In addition, another large red nematode stretching through the intestinal wall to the abdominal cavity was found. The major part of its body was rolled into the fish intestinal wall, while the remaining part passed through the serosa (Figure 1D). In the abdominal cavity, a light brown nematode, 1.5 cm long, was found (Figure 1E). All species of parasites were identified at necropsy.

Parasite examination and classification
The isolated parasites and their eggs from the diseased fish muscle, digestive tract, and mesentery were identified according to the method of Mikailov et al. (1992).

The tiny brown was identified as the genus *Anisakis* sp., according its main characteristic, a three-lipped mouth. The other important characteristic of the stomach and intestine of this worm was the absence of a wrinkly cecum (Figure 2A). Another nematode (4.0 cm long) was identified as the genus *Eustrongyloides* sp. according to its mastoid type mouth with 6 hooks and without lips (Figure 2B). Its cuticle layer was link-shaped and its surface without a spine. The long and non-expanding esophagus of this worm was the main characteristic.

Furthermore, an acanthocephalid worm was detected. It was classified as the species *Echinorhynchus gadi*, according to its main characteristics, an invaginable, hook-bearing proboscis at the front of the body (Figure 2C). There was a spine at the lateral-anterior end of the worm. The surface of the proboscis had 15-17 vertical hooks and each row had a small hook.
A cestode was discovered in the infected fish stomach. The uniqueness of this cestode was the structure of the relatively large scolex with 4 bothridia anteriorly and a retractable proboscis (Figure 2D). The worm was identified as a member of the order Tetrarhynchidea, species Lepidopus caudate (Grabda, 1991; Möller, 1986a, b).

The digenean Brachyphallus crenatus was found in the intestine. The body was shuttle-shape, 0.2 cm in diameter and 1.2 cm long (Figure 2E) (Kabata, 1995a, b).

Although the eggs found in diseased eel muscle was identified as cestode eggs, no adults were detected and therefore the sixth

Figure 1A–E. Gross parasitological findings of diseased short-finned eels. (A) Numerous petechial hemorrhages on the serosa of the stomach (arrows). (B) A light brown tiny nematode in the abdominal cavity (arrow). (C) A red nematode in the abdominal wall (arrow). (D) A red nematode passing through the intestinal wall to the abdominal cavity (arrow). (E) Nematode in the abdominal wall (arrows).
type of worm could not be identified. No pathogenic bacteria were isolated.

Discussion
In Taiwan, eels have been cultured for more than five decades. The species include Japanese eel (*Anguilla japonica*), European eel (*Anguilla anguilla*), and American eel (*Anguilla rostrata*). The Japanese eel is the most important cultured species since it grows well in Taiwanese ponds, while other eel species experience temperature related difficulties and serious disease problems (Chen, 1990). The main parasitic diseases of cultured Japanese eel in Taiwan have been reported by Lin et al., 1996: Parasitosis of the gills include *Trichodina* sp, *Apiosoma*, *Glossatella*,

![Figure 2A—E. Parasite examination and classification. (A) A three-lipped mouth is characteristic of *Anisakis* sp. (arrow). (B) *Eustrongyloides* sp. showing a mastoid around its mouth with six hooks (arrow). (C) *Echinorhynchus gadi* with an invaginable, hook-bearing proboscis in the front (arrow). (D) *Lepidopus caudatus*. The scolex with four retractable proboscis (arrow). (E) *Brachyphallus crenatus* with two circular suckers and muscular walls (arrows).](image-url)
Dactylogyrus sp, Pseudodactylogyrus sp, Cyclochaeta domerguei, and Gyrodactylus sp. In addition, Lernaea sp. and Myxicium sp. were found in the gills of eels, while Anguillicola crassus infects the swim bladder (Lin et al., 1996).

Our study is the first report on the importation of parasitized short-finned eels into Taiwan. Five species of parasites were found in the same batch of short-finned eels: Anisakis sp., Eustrongyloides sp., Echinorhynchus gadi, Lepidopus caudatus, and Brachyphallus crenatus.

Necropsy showed that there were petechial hemorrhages on the stomach of diseased eels. It may be caused by nematodes passing through the intestinal wall. Parasites and eggs were found in the muscle of the diseased fish. This parasitizing and migration of parasites damage fish organs and muscles. It may cause an appetite decrease, decreased activity, and even death. Interestingly, Anisakis sp., Eustrongyloides sp., Echinorhynchus gadi, Lepidopus caudatus, and Brachyphallus crenatus were found in the same individual ill fish at the same time in this case. A nematode was identified as a member of the Family Anisakidae. Fish and member of the Class Cephalopod are the main second intermediate hosts for this worm (Möller, 1986a, b). However, the final hosts are marine mammals, especially dolphins (Köie, 2001). Another nematode Eustrongylides sp., which deposits larvae in the fish body cavity, digestive tract, and muscle, was also found. Usually, birds and sturgeons are its final hosts (Mikailov et al., 1992). Eustrongylides sp. and Anisakis sp. has been reported to be able to infect humans.

The larvae of Tetrarhynchidea are often seen in marine fish. Commonly, they are found in the muscle of infected fishes, but we found the worm parasite in the stomach of the eel in this case. These parasites decrease the economic value of the cultured fishes. The damage caused by the worms to their hosts is mainly caused by migration of metacercariae (Kabata, 1985a). In this case, we found many petechial hemorrhages on the stomach serosa presumably caused by this worm.

The short-finned eel of this study is a much valued fish in Taiwan. These eels are protected as wildlife, but during the last decade, the increased application of pesticides and industrial pollution of swamps have caused the eels to disappear from many of their natural habitats (Lin et al., 1996). To compensate for this, animal husbandry has imported short-finned eels from abroad. It is unknown whether the parasites identified in the batch of imported eels in this study can infect Taiwan’s native eels or not. We suggest that infected eels should be destroyed, by incineration or by burying them in quick lime, because of their potential hazard to Taiwan’s aquaculture.

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References


