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EYE FLUKE (*DIPLOSTOMUM SPATHACEUM*) OF FISHES FROM THE UPPER SALMON RIVER NEAR OBSIDIAN, IDAHO

Richard Heckmann[1]

ABSTRACT.— Following a preliminary survey (1981) of diplostomatosis in fish from the Salmon River near Obsidian, Idaho, an extensive survey was conducted during the summer of 1982. From the initial sampling site on the Salmon River, 98 percent of 384 sculpin, *Cottus bairdi*, 8 percent of 317 salmonids, and 13 percent of 16 Dace and suckers were infected with *Diplostomum spathaceum*. Upriver from the initial sampling site and from three drainages entering the Salmon River 28 percent of 185 sculpin and 1 percent of 70 salmonids were infected with *D. spathaceum*. The number of worms per eye was greater for sculpin (1 to 100+) than for salmonids (1 to 18) from the same area. The metacercariae of *D. spathaceum* occupy the vitreous body-retina area of infected fish. There is a prominent pathology associated with the infection, including detachment of the retina. Sculpin represent an indicator species for the range of diplostomatosis. The high infection rate of sculpin is associated with their bottom-dwelling characteristic and with their feeding habits.

Following a preliminary study of the eye fluke of fishes from the Upper Salmon River during the summer of 1981, an extensive survey was conducted on the incidence of *Diplostomum spathaceum* of fishes from the same locality during 1982.

Diplostomum spathaceum (Rudolfi 1819) (Diplostomidae), the fish eye fluke that causes the disease diplostomatosis (diplostomatiasis), has been reported in many areas of North America and other parts of the world. Extensive surveys have been conducted in Utah concerning incidence, life history, and pathology (Heckmann 1978). Diplostomatosis, which is due to the presence of the metacercarial stage of this parasite in fish, causes cataracts of the lens and damage to the vitreous body and the retina of the eye.

Diplostomum spathaceum is a digenetic trematode that has numerous synonyms in the literature (McDonald 1969).

The life cycle of *D. spathaceum* includes the adult parasite that lives in the intestinal tract of a piscivorous bird. The eggs from the adult trematode are passed in fecal deposits from the definitive host. The eggs embryonate in water and release a free-swimming miracidium in two to three weeks. The miracidium has approximately 24 hours in which to locate and infect the first intermediate host, which is a species of snail. In the snail the mother and daughter sporocysts develop in liver tissue. The daughter sporocysts release free-swimming cercariae in approximately 6 weeks after miracidial penetration of the snail. The cercariae have from 24 to 48 hours to penetrate the second intermediate host. Fish are the most common second intermediate hosts; however, infections in amphibians, reptiles, and mammals have also been reported (Ferguson 1943). Once the cercariae have penetrated the second intermediate host, they lose their forked tails and migrate to the lens tissue, where the metacercariae develop in 50 to 60 days (Erasmus 1958). When infected lens tissue is eaten by a bird, the adult fluke develops in the gut within five days (Oliver 1940). To date, 15 species of snails, 70 species of fish, and 37 species of birds have been reported worldwide as hosts for *D. spathaceum* (Palmieri et al. 1977).

Currently there are several studies underway throughout this country to determine the correct binominal name for the fish eye fluke. Consensus is that the metacercariae inhabiting the orbit of fish eyes in the Upper Salmon River is *D. spathaceum*. Hoffman (1970) states that the genus *Diplostomum* includes metacercarial stages in the eyes of fish. He lists two species for the eyes; *D. spathaceum* found in the lens with a distinct hindbody and *D. huronense* found in the vitreous chamber, a worm less than three times

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as long as broad with a distinct hindbody. In both cases gulls are listed as the primary definitive host, with *Lymnaea* snails as the preferred first intermediate host. According to the above characteristics, the eye fluke we have studied for this report should be *D. huronense*, but Dubois (1935) and Dubois and Mahon (1959) consider *D. huronense* to be a synonym for *D. spathaceum*. Thus, we will consider the fish eye fluke of the Upper Salmon River to be *D. spathaceum*.

Beginning in June and ending in September, sampling was conducted in a series of four periods in 1982. One of the major objectives of this study was to determine the number of metacercariae in fish from (a) the bank and (b) midwater of the Upper Salmon River and streams draining into the river.

Materials and Methods

Four collection trips were scheduled and completed to the Upper Salmon River area. During each trip, fish were collected by one of three methods: electrofishing, hook and line, and nets. Where possible, samples were obtained from fishermen. Each fish was examined for eye flukes by removing the soft tissue from the orbit of the eye, placing the contents in a petri dish, and examining the sample with a dissecting microscope. Samples of eyes that contained numerous metacercariae (80 to 100+ per eye) were fixed in 10 percent formalin for sectioning and staining to determine the pathology of the infection. Fish were sampled from the Upper Salmon River near Obsidian, Idaho, and from four other locations upriver that are identified in Tables 1–3.

Results

The results of fish samples taken from the Upper Salmon River area are found in Tables 1, 2, and 3. From these data it is apparent that the mottled sculpin (*Cottus bairdi*) is the most susceptible to the eye fluke. The sculpin was used as a primary indicator species for other areas and feeder streams (Table 4). Whitefish (*Prosopium williamsoni*) (Table 2) carried the second highest number of metacercariae within the eye orbit. Chinook salmon (*Oncorhynchus tshawytscha*) are relatively free of the fish eye fluke. These tables also show that the infection in fish reached a peak toward the end of the summer.

Fish sampled from upriver sites contained a lower number of metacercariae (Decker Flat) to no worms for fish from feeder streams and the headwaters of the Salmon River (Tables 2 and 4). Fish inhabiting slow-moving water and pools in the main river are more susceptible to cercarial invasion than those in fast water (Table 1). As expected, larger fish of the same species in general carry a greater number of worms than smaller fish (Table 1).

Histological examination of the infected fish indicated a vitreous body-retina location for the worms (Fig. 1).

The metacercariae cause a detachment of the retina from the outer vascular and fibrous coats (choroid, sclera). Thus, heavily infected fish (40+ worms) are blind. The eye fluke found in fish in Utah inhabits the lens.

The pathological effects of *Diplostomum spatheceum* upon the fish host are many. Examination of those fish blinded with cataract and containing a heavy burden or larval metacercariae revealed stunted growth (length, girth, and weight), abnormal feeding behavior (lack of response to visual stimuli), and decreased vital acuity (Palmieri et al. 1977). Ashton et al. (1969) reported that larvae migrate to the eye via vascularvenous channels and showed that the lens, vitreous, or cortex of the eye may be proliferated with metacercariae. In older fish, chronic infections and pronounced subacute inflammatory reactions in the vitreous involving heterophils, eosinophils, and macrophages with ingested lens material occurred.

Visual acuity for infected fish can be slightly hampered or lost due to worm burden. In addition to visual loss and concomitant pathogenesis, fish show retarded growth and a change in food habits. Fishermen consider the fluke as one of the reasons for a decrease in number of fish caught on artificial lures.

Discussion

Due to the unique nature and location of this fluke within the eye of the fish and due to its associated pathogenicity, much time

TABLE 1. Summary of all samples from the mottled sculpin, *Cottus bairdi*, checked for the eye fluke, *Diplostomum spathaceum* during 1982, Salmon River, Idaho.

Location	Date of sample in 1982	Number of fish	Size class*	Number with eye fluke	Eye flukes per eye
Salmon River (Side channel)	28 June	9	M	9	6
	27 July	15	M and L	14	23
	29 July	10	M	10	16
	25 Aug	3	L	3	48
		6	M	6	18
		12	S	12	5
	1 Oct	8	L	8	7
		4	M	4	5
		2	S	2	2
Salmon River (Middle channel)	28 June	0	High water	No sample	
	27 July	32	M and L	31	39
	25 Aug	12	L	12	88+
		9	M	9	43
		10	S	10	11
	1 Oct	1	XL	1	100+
		14	L	14	81+
		11	M	11	35+
		6	S	6	27+
Salmon River (Main channel)	28 June	0	High water	No sample	
	29 July	2	M	2	10
	25 Aug	4	L	4	56
		14	M	14	7
		4	S	4	5
	1 Oct	5	L	5	7
		4	M	3	6
		2	S	1	6
Frenchman Creek	28 July	12	M	0	0
Headwaters (Salmon River)	28 July	10	M	0	0
Salmon River (Decker Flat)	25 Aug	9	L	8	3
		15	M	13	3
		7	S	4	1
Beaver Creek	26 Aug	12	M	0	0
		7	S	0	0
Frenchman Creek	26 Aug	2	L	0	0
		10	M	0	0
		3	S	0	0
Headwaters (Salmon River)	26 Aug	6	L	0	0
		12	M	0	0
		12	S	0	0
Salmon River (Decker Flat)	2 Oct	3	L	3	2
		21	M	21	2
		2	S	2	1
Beaver Creek	2 Oct	8	L	0	0
		12	M	0	0
		2	S	0	0
Frenchman Creek	2 Oct	4	L	0	0
		10	M	0	0
		4	S	0	0
Headwaters (Salmon River)	2 Oct	2	M	0	0

*The sculpin were divided into four size classes based on total length (TL). XL: greater than 115 mm TL, L: 95 to 115 mm TL, M: 85 to 94 mm TL, S: 65 to 84 mm TL.

**When there is more than 100 metacercariae in the orbit of a fish eye, a plus (+) designation is used.

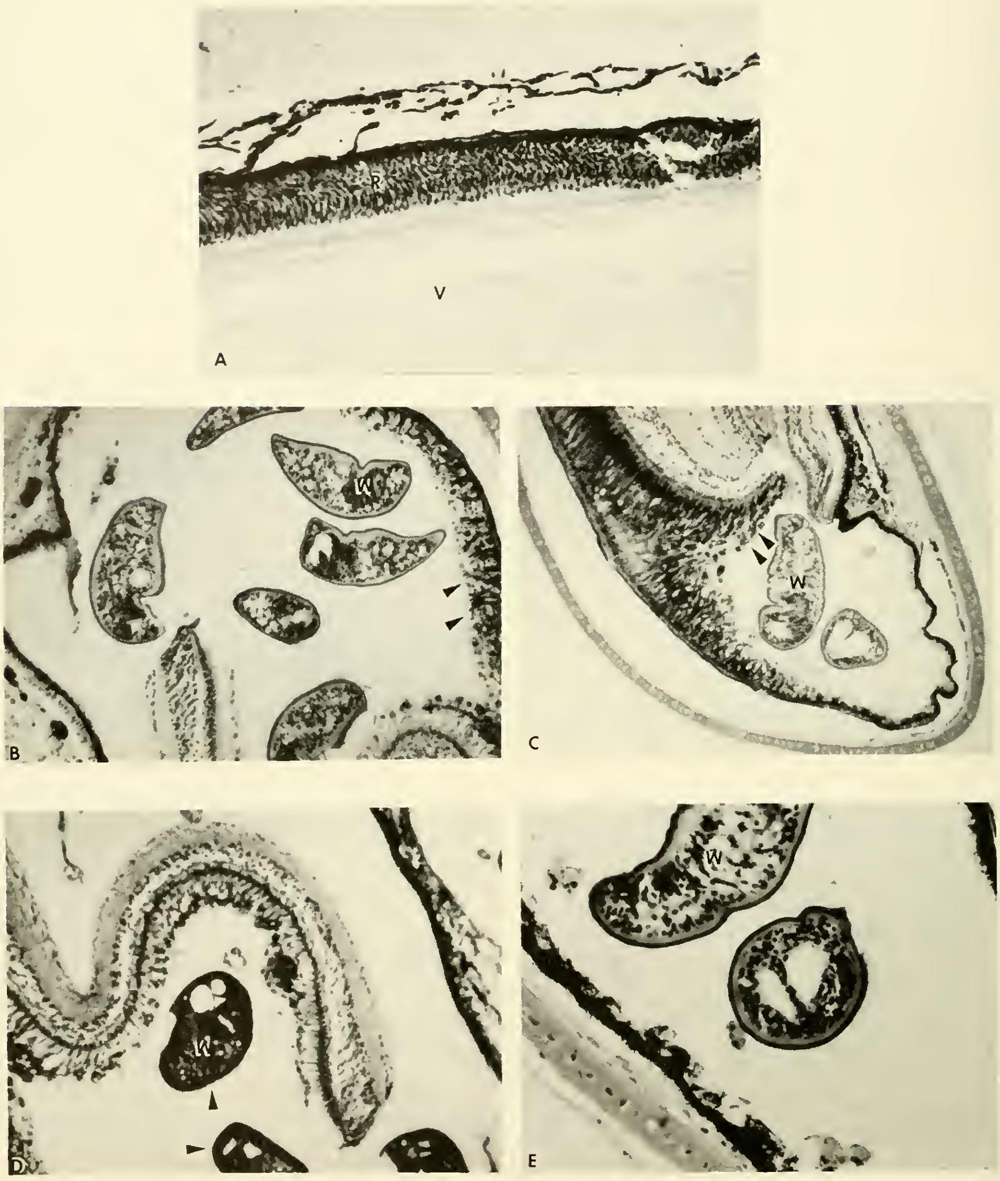

Fig. 1. Figure A represents normal tissue found in the vitreous-retina area of a fish eye. B,C,D,E show infected eyes of a sculpin in which the *Diplostomum* metacercariae occupy the vitreous-body (V)–retina (R) area of fish. Note the detachment (arrow) of the retina due to metacercarial invasion (B,C).

and money have been spent in an attempt to control and ultimately eradicate it. The greatest damage caused by this fluke is blindness and death in a variety of game fish throughout the world and specifically in Utah and Idaho.

The survey completed on the potential hosts from the ichthyofauna of the Upper Salmon River and drainages is quite extensive. During 1982, 384 sculpin were obtained from the main Salmon River near Obsidian, Idaho, of which 98 percent were infected with the eye fluke (1 to 100+ worms per eye); 185 sculpins were sampled upriver from the first collection site and from drainages into the river, of which 28 percent were infected (1 to 3 worms per eye); 317 salmonids and 16 Dace and Suckers were sampled from

Table 2. Summary of all samples from fish representing the family Salmonidae checked for the fish eye fluke, *Diplostomum spathaceum*, 1982, Salmon River, Idaho.

Location	Date of sample in 1982	Species of fish	Number of fish	Size of fish	Number with eye flukes	Eye flukes per eye
Salmon River (Side channel)	28 June	Chinook *Oncorhynchus tshawytscha*	35	Fingerling	1	1
		Steelhead *Salmo gairdneri*	12	Catchable 10–14 inches (TL)*	1	1
Salmon River (Main channel)	29 June	Whitefish *Prosopium williamsoni*	3	10–16 inches (TL)	2	18
		Steelhead *Salmo gairdneri*	4	10–14 inches (TL)	0	0
		Rainbow Trout *Salmo gairdneri*	1	12 inches (TL)	0	0
	30 June	Whitefish *Prosopim williamsoni*	2	10–14 inches (TL)	2	15
		Steelhead *Salmo gairdneri*	3	10–16 inches (TL)	0	0
	1 Aug	Whitefish *Prosopium williamsoni*	1	12 inches (TL)	0	0
	27 Aug	Rainbow Trout *Salmo gairdneri*	5	10–15 inches (TL)	4	2
Salmon River (Main channel)	27 Aug	Steelhead *Salmo gairdneri*	6	10–14 inches (TL)	1	1
		Chinook *Oncorhynchus tshawytscha*	17	Fingerling	2	1
Salmon River (Main channel)	28 July	Brook Trout *Salvelinus fontinalis*	1	15 inches (TL)	0	0
		Rainbow Trout *Salmo gairdneri*	3	9–14 inches (TL)	1	1
Salmon River (Side channel)	29 July	Chinook *Oncorhynchus tshawytscha*	12	Fingerling	0	0
Holding tank (Salmon River water)	29 July	Chinook *Oncorhynchus tshawytscha*	12	Fingerling	0	0
Salmon River (Middle channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	15	Fingerling	0	0
Salmon River (Side channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	32	Fingerling	0	0
Salmon River (Main channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	14	Fingerling	1	1
Salmon River (Middle channel)	25 Aug	Rainbow Trout *Salmo gairdneri*	7	9–15 inches (TL)	3	3
Salmon River (Side channel)	25 Aug	Rainbow Trout *Salmo gairdneri*	2	10–12 inches (TL)	2	1
Salmon River (Side channel)	25 Aug	Chinook *Oncorhynchus tshawytscha*	5	Spawners 26–36 inches (TL)	0	0
Salmon River (Side channel)	26 Aug	Chinook *Oncorhynchus tshawytscha*	6	Spawners 26–42 inches (TL)	0	0

*TL: total length of fish.

Table 2 continued.

Location	Date of sample in 1982	Species of fish	Number of fish	Size of fish	Number with eye flukes	Eye flukes per eye
Holding Tank (Salmon River water)	26 Aug	Chinook *Oncorhynchus tshawytscha*	26	Fingerlings	1	1
Salmon River (Middle channel)	1 Oct	Chinook *Oncorhynchus tshawytscha*	19	Fingerlings	1	1
Salmon River (Main channel)		Chinook *Oncorhynchus tshawytscha*	6	Fingerlings	0	0
Salmon River (Side channel)		Chinook *Oncorhynchus tshawytscha*	25	Fingerlings	0	0
Holding Tank (Salmon River water)	1 Oct	Chinook *Oncorhynchus tshawytscha*	20	Fingerlings	1	1
Salmon River (Middle channel)	1 Oct	Rainbow Trout *Salmo gairdneri*	3	7–12 inches (TL)	1	3
Beaver Creek	28 July	Brook Trout *Salvelinus fontinalis*	3	6–10 inches (TL)	0	0
Frenchman Creek	28 July	Brook Trout *Salvelinus fontinalis*	3	5–9 inches (TL)	0	0
Frenchman Creek	28 July	Chinook *Oncorhynchus tshawytscha*	1	Fingerling	0	0
Salmon River (Decker Flat)	25 Aug	Rainbow Trout *Salmo gairdneri*	2	6–7 inches (TL)	0	0
		Brook Trout *Salvelinus fontinalis*	2	5–6 inches (TL)	0	0
Beaver Creek	26 Aug	Brook Trout *Salvelinus fontinalis*	7	4–10 inches (TL)	0	0
Frenchman Creek	26 Aug	Brook Trout *Salvelinus fontinalis*	2	5–8 inches (TL)	0	0
Headwaters	26 Aug	Brook Trout *Salvelinus fontinalis*	1	5 inches (TL)	0	0
Salmon River (Decker Flat)	2 Oct	Chinook *Oncorhynchus tshawytscha*	26	Fingerlings	1	1
Beaver Creek	2 Oct	Rainbow Trout *Salmo gairdneri*	4	8–10 inches (TL)	0	0
		Brook Trout *Salvelinus fontinalis*	7	3–8 inches	0	0
Frenchman Creek	2 Oct	Brook Trout *Salvelinus fontinalis*	19	7–12 inches (TL)	0	0

*TL: total length of fish.

the first site, of which 81 percent (1 to 18 worms per eye) and 13 percent (1 worm per eye) were infected, respectively; and upriver only 1 percent of the 70 salmonids was infected with 1 worm per eye. I have checked most of the fish species in that part of the Salmon River for metacercariae. The sculpin, *Cottus bairdi*, appears to be an excellent indicator host for the eye fluke. The fluctuation in numbers of metacercariae per infected fish correlates with sporocyst stages in the snail, which will be the topic for another paper. Diplostomatosis has been reported in Russia, Germany, Finland, Ireland, Mexico, Italy, Africa, England, Scotland, and the United States (Hoffman 1970, Davies 1972).

Diplostomatosis is considered to be specific for freshwater fish. Dogiel (1962 and 1934) showed that lampreys and salmon become infected with the eye fluke during spawning migrations to fresh water. It is possible that salmon fry become free of *Diplostomum* after they return to the sea (Dogiel 1962).

Direct contact between the fish and its parasite is required for cercarial penetration. Thus, the fish must swim into the infected areas since cercariae have a limited swimming ability. Slyczynska-Jurewuz (1959) utilized cages to show that fish have a greater tendency to get diplostomatosis as they move closer to the shore. This is due to the preferred habitat of snails. The maximum rate of infection occurs during the months of June and July, coinciding with the peak of cercarial discharge (Kamenskii 1964). The peak infection occurred during August and September for the current study.

Snails prefer warm, clean, slow-moving water with vegetation in which to live (Macon 1950). This was also observed for snails infected with sporocysts from the Upper Salmon River. Lymnaeidae are generally found in water with at least 15 parts per million of bound carbon dioxide and with a pH of 7 or above (Pennak 1953). These snails are known to eat both plant and animal material but prefer vegetation when available. They live approximately one and a half years and have been known to estivate up to 3 years (Pennak 1953). Lymnaeids usually are found in less than 4.5 feet of water and can live without free oxygen (Cheatum 1934). Young snails are more susceptible to miracidial penetration than older snails, which appear to have some type of resistance (Cort et al. 1957).

Fish and other cold-blooded vertebrates seem to have a fairly low resistance to metazoan parasites; thus, extensive damage to host tissue is not uncommon (Snieszko 1969). There continues to be debate concerning the general pathologic effects of *D. spathaceum* infecting the fish lens. Visual perception of infected fish varies from total blindness (Ferguson 1943a) to impaired vision (Ghittino 1974).

Pathologic effects to the eye by the parasite are characterized by inflammation, vascular disturbances, exophthalmia, destruction of lens tissue, necrosis, ulceration of the cornea, and eventual loss of the lens. Secondary damage can occur through the development of *Saprolegnia* within the necrotic tissue (Palmieri et al. 1976).

Diplostomum spathaceum causes several diseases of the eye region in a variety of fish. First signs of an infection are a number of localized swellings or red patches on the fins, body, or eye area where cercariae penetrate and cause rupture of the surface blood vessels. In certain reported cases, mass entry of cercariae through the skin or gills causes obstruction of the blood vessels in the gills, resulting in asphyxia, shock, and damage to the nervous system. Once the ultimate site location is found, metacercariae penetrate the iris, retina, and lens capsule by means of anterior spines and secretions of the anterior penetration glands and encyst in these tissues or within the vitreous body or crystalline lens of the infected fish, causing immediate hemorrhaging of the local area. The worms may

TABLE 3. Summary of all samples from Dace and Suckers checked for the fish eye fluke, *Diplostomum spathaceum*, 1982, Salmon River, Idaho.

Location	Date of sample in 1982	Species of fish	Number of fish	Size of fish	Number with eye flukes	Eye flukes per eye
Salmon River (Side channel)	28 June	Dace (*Rhinichthyes*)	4	2–4 inches (TL)	1	1
Salmon River (Main channel)	1 July	Sucker (*Catostomus*)	1	14 inches (TL)	0	0
Salmon River (Main channel)	27 July	Dace (*Rhinichthyes*)	1	3 inches (TL)	0	0
Salmon River (Side channel)	28 July	Dace (*Rhinichthyes*)	4	3–4 inches (TL)	1	1
Salmon River (Side channel)	25 Aug	Dace (*Rhinichthyes*)	6	4–5 inches (TL)	0	0

*TL: total length of fish.

TABLE 4. Range of eye fluke infection; from initial sampling area along the Upper Salmon River to the headwaters of the Salmon River: *Cottus bairdi* (Sculpin) indicator species.

Location of sample	Miles from initial sample site	Species	Date in 1982	Total fish	Number infected	*Number of eye flukes per eye
Salmon River (Initial site)	0	Sculpin	27 July	32	31	39
Frenchman Creek	22	Sculpin	28 July	12	0	0
Headwaters (Salmon River)	23	Sculpin	28 July	10	0	0
Salmon River (Initial site)	0	Sculpin	25 Aug	31	31	46+
Salmon River (Decker Flat)	9	Sculpin	25 Aug	31	25	2
Beaver Creek	18	Sculpin	26 Aug	19	0	0
Frenchman Creek	22	Sculpin	26 Aug	15	0	0
Headwaters (Salmon River)	23	Sculpin	26 Aug	30	0	0
Salmon River (Initial site)	0	Sculpin	1 Oct	32	32	61+
Salmon River (Decker Flat)	9	Sculpin	2 Oct	26	26	2
Beaver Creek	18	Sculpin	2 Oct	22	0	0
Frenchman Creek	22	Sculpin	2 Oct	18	0	0
Headwaters (Salmon River)	23	Sculpin	2 Oct	2	0	0

*When there is more than 100 metacercariae in the orbit of a fish eye, a plus (+) designation is used.

stay viable from 10 months to two years or longer, causing chronic blindness due to parasitic cataract, keratoglobus, herniation, and tumor formation. During this time fish cannot feed normally, and they stop growing or die.

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