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The Susceptibility of Four Salmonid Species to the Eyefluke, Diplostomum spathaceum[2]

Abstract

Susceptibility to *Diplostomum spathaceum* differed significantly (t-test, $p = 0.05$) among rainbow trout (*Salmo gairdneri*), cutthroat trout (*Salmo clarki*), brook trout (*Salvelinus fontinalis*), and coho salmon (*Oncorhynchus kisutch*) in terms of mean survival times after exposure to orally administered cercariae. Generally, rainbow trout were the most resistant while coho salmon were the least resistant. Increased survival time of fish apparently was directly related to increased water temperature, while survival time was inversely related to dosage of cercariae administered or duration of exposure to cercariae.

Introduction

Diplostomatosis is a disease caused by metacercariae of the trematode *Diplostomum spathaceum*. It is a serious fishery management problem in many areas throughout the United States, Europe, and Africa (Palmieri *et al.* 1976b), and is a major problem in many trout waters in Idaho (Bakke 1977), Washington (Crawford 1973), Colorado (Davies *et al.* 1973), and Utah (Bakke 1977, Palmieri *et al.* 1977), where heavy aquatic vegetation allows the intermediate snail hosts to live.

The life cycle of *D. spathaceum* is fairly typical for strigeoid trematodes and has been discussed in detail by several authors (Ashton *et al.* 1969, Davies *et al.* 1973, Palmieri *et al.* 1976b, 1977). A problem in trout management arises from the fact that most members of the family Salmonidae appear to be susceptible to these eye flukes, with several members of the genera *Salmo* and *Salvelinus* reported to be infested with D. *spathaceum* (Davies *et al.* 1973; Palmieri *et al.* 1976b, 1977; Hendrickson 1978), and members of the genera *Oncorhynchus* (Bakke 1977) and *Coregonus* (Rau *et al.* 1979) infested with closely related eye flukes.

Fish are usually infected directly by motile cercariae of *D. spathaceum* penetrating the fish's integument (Davis 1936, Ratanarat-Brockelman 1974), although ingestion of metacercariae in infested snails is an alternate path of infection (Becker and Brunson 1966). Strigeoid metacercarie migrate rapidly to their target organs in the fish host (Johnson 1971, Ratanarat-Brockelman 1974) and cause severe damage both along the migration route and in the target organ, which for *D. spathaceum* is the lens of the

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eye (Ashton *et al.* 1969, Larson 1965, Ratanarat-Brockelman 1974). Parasitization of the lens by *D. spathaceum* metacercariae can cause eye cataracts (diplostomatosis), which lead to blindness, abnormal feeding, and stunted growth (Crawford 1973, Davies *et al.* 1973, Palmieri *et al.* 1976b, 1977). Aside from mortalities that may occur after infestation (Crawford 1973, Bakke 1977, Sweeting and Powell 1977), pathological changes in individual fish cause a reduction in the overall quantity and quality of the sport catch (Davies *et al.* 1973). Therefore eye flukes have a serious potential to damage recreational trout fisheries in many areas. Since susceptibility to these parasites varies among salmonid species, it is important for successful management of fisheries to understand the differences in susceptibility. It has been found that brown trout (*Salmo trutta*) are more resistant than rainbow trout (*Salmo gairdneri*) to infestations with *D. spathaceum* (Betterton 1974, Henderson 1978). Mamer (1978) found *Diplostomum* sp. in significantly greater intensities in rainbow trout than in cutthroat trout (*Salmo clarki*). The state of Colorado stocks brown trout to take advantage of its high resistance to *D. spathaceum* (Davies *et al.* 1973).

This study was done to determine which species of salmonid fishes stocked in the state of Washington—rainbow trout (*S. gairdneri*), cutthroat trout (*S. clarki*), brook trout (*Salvelinus fontinalis*), and coho salmon (*Oncorhynchus kisutch*)—has the greatest resistance to cercarie of *D. spathaceum*.

Materials and Methods

Snails (*Lymnaea palustria* and *Physa propinqua*) were collected from aquatic vegetation in North Heron Lake in Grant County, Washington. In the laboratory, snails were kept in aquaria containing lake water at room temperature and were maintained on a diet of lettuce leaves and vegetation from their natural habitat. Live cercariae of *D. spathaceum* were readily identified under a dissecting microscope by their characteristic movements and forked tails. Approximately 3,000 cercariae could be obtained from a single infested snail by crushing the hepato-pancreas area with dissecting forceps. Special care was taken in choosing cercariae of similar maturity, as judged by size and degree of activity. Only the most active cercariae were used in experiments, while those in sporocysts were excluded. The snail, *L. palustria*, served as the laboratory source of all cercariae.

Rainbow trout, cutthroat trout, brook trout, and coho salmon averaging 15 cm in total length were used to test resistance to live cercariae. Coho salmon were obtained from the Washington Department of Fisheries hatchery at Issaquah, while cutthroat, brook, and rainbow trout were obtained from the Wahington Department of Game hatcheries at Tokul Creek, Chelan, and Arlington, respectively. Fish received an initial prophylactic Formalin treatment and were kept under laboratory conditions at least two weeks before experimental use. All fish received standard diets of salmon meal used by the hatchery at the University of Washington School of Fisheries.

Fish were artificially infested by inserting individually counted live cercariae in physiological saline into the stomach via the oral cavity with a 30-cc syringe and rubber tube (use of the tube prevented physical damage to the fish). Artificially infested fish were kept at 10° or 21°C during the experiment and signs of the disease were noted. We administered an oral dose of either 50 or 300 live cercariae to eight fish of each of the four species which were held at 15°C, and 50 cercariae to eight fish of each species except cutthroat which were held at 21°C. Control fish received an equal volume of physiological saline administered orally.

Natural penetration of cercariae was studied in experimental fish exposed to live cercariae emerging from infested snails. An experiment using six fish of each of the four fish species was performed by exposing them to 1000 live snails of which approximately three percent were infested with emerging cercariae. Exposures were done at 21°C for either 15 min or 30 min or at 15°C for 60 min. Control fish were treated similarly in all respects except for exposure to cercariae or snails.

Results

All fish experimentally exposed to orally administered cercariae of the eyefluke died before the 270 day arbitrary end point set for these experiments. The average survival time of the four Salmonid species exposed to 50 orally administered *D. spathaceum* cercariae at 15°C differed greatly, ranging from the lowest survival average of 30 days in coho salmon to the highest of 97 days for rainbow trout (Table 1). The survival

TABLE 1. Mean survival time (days) of four species of Salmonidae after oral administration of live cercariae. Cutthroat trout were not tested at 21°C.

	Number of Cercariae and Temperature		
Species*	50 (21°C) Mean ± S.D.	50 (15°C) Mean ± S.D.	300 (15°C) Mean ± S.D.
Rainbow Trout	210 ±74.4	97 ± 8.6	40 ± 19.9
Cutthroat Trout	—	60 ± 15.9	45 ± 13.8
Brook Trout	120 ± 29.9	43 ± 9.4	56 ± 3.3
Coho Salmon	75 ±28.5	30 ± 0.7	30 ± 0.4

*Eight fish were used as controls for each species and in each experimental treatment.

times of the four species of experimental fish were significantly different (t-test, $p = 0.05$). The unexposed control fish of all four species survived until the end of the experiment (270 days), giving a significant difference (t-test, $p = 0.05$) in survival time between experimental and control fish. At increased temperature (21°C), coho salmon still survived the shortest time even though survival times for all three species tested were increased (Table 1), and these were significantly different (t-test, $p = 0.05$). Increasing the number of cercariae administered orally to 300 (Table 1), still showed coho salmon with the shortest survival (30 days), but survival time among rainbow and cutthroat trout was not significantly different (t-test, $p = 0.05$).

Using infested snails to determine the effect of exposure to emerging cercariae, we observed that rainbow trout were most resistant to cercarial penetration and that coho salmon appeared to be the least resistant (Table 2). Mean survival time declined as the exposure time was increased. At 21°C the mean survival time of all four species exposed for 30 minutes was significantly shorter (t-test, $p = 0.05$) than that of fish exposed for 15 minutes (Table 2). All control fish survived the entire experimental period.

Discussion

Determination of the most important variable is difficult, but, the survival time of fish appeared to be related to water temperature, exposure time to cercariae, and cercarial

TABLE 2. Mean survival time (days) of four species of Salmonidae exposed to snails with emerging cercariae.

Species*	Exposure Time in Minutes and Temperature 15 (21°C) Mean ± S.D.	30 (21°C) Mean ± S.D.	60 (15°C) Mean ± S.D.
Rainbow Trout	76 ± 30.0	16 ± 2.3	10 ± 0.4
Cutthroat Trout	35 ± 6.9	12 ± 2.1	9 ± 2.1
Brook Trout	62 ± 24.9	11 ± 0.4	7 ± 1.2
Coho Salmon	30 ± 7.4	12 ± 0.5	4 ± 1.2

*Six fish were used as controls for each species and in each experimental treatment.

dosage. Fish survived longer when infested at 21°C than at the lower temperature of 15°C. It is well established that fish initiate antibody formation more quickly at higher temperatures than at lower temperatures (Anderson 1974, Corbel 1975, Patterson and Fryer 1974) and there is evidence that fish form specific antibodies against metazoan parasites (Molnar and Berezi 1965, Harris 1972, Cottrell 1977). However, it is not well established how fish acquire resistance to internal metazoan parasites (Snieszko 1969, Anderson 1974). If antibodies play an active role in fish resistance to the eye fluke, then the fish may initiate a specific immune response against *D. spathaceum* more rapidly at high temperatures than at low temperatures, thereby reducing the number of cercariae that invade the fish. Higher water temperatures within the optimal temperature range should favor the fish's survival, even though cercariae are more active at higher temperatures (Becker and Brunson 1966).

In the past, chemical and physical control of the snail hosts of *D. spathaceum* have proved fruitless (Palmieri *et al.* 1976a). Until a suitable method of control is found, fishery biologists should consider the high resistance of certain species of Salmonidae to *D. spathaceum* as a management tool. The significant observation for management purposes is that coho salmon were always the first fish to die and that rainbow trout were generally the most resistant to *D. spathaceum*. From our results, coho salmon would probably give fewer returns to the angler as compared to rainbow trout. Cutthroat trout or brook trout would be a secondary choice to stock if rainbow trout were not available. If feasible from an economic and sport point of view, brown trout would seem to be an even better choice than rainbow trout (Davies *et al.* 1973, Betterton 1974). Crawford (1973) has indicated that stocking legal size trout in known infested waters would also help provide a good sport fishery.

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