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CHONDROCOCCUS COLUMNARIS DISEASE OF FISHES:
INFLUENCE OF COLUMBIA RIVER FISH LADDERS*

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ABSTRACT

Columbia River fish ladders were surveyed as a possible ecological niche for Chondrococcus columnaris, the causative agent for columnaris disease of fishes. Water samples from Bonneville, McNary, Priest Rapids, and Rocky Reach fish ladders during periods of warm water temperature and high population density of fishes showed C. columnaris levels of from 0.06 to 4.1 organisms per ml. Samples taken upstream or downstream from the ladders were consistently negative. Average agglutinating titers and incidence of C. columnaris infection in largescale suckers were higher at the Bonneville ladder than at a site several miles downstream. Coho salmon from an upper-river fish ladder (Rocky Reach) showed a higher incidence of infection and greater antibody production than at the down-river Bonneville ladder. It is concluded that fish ladder facilities on the Columbia River are important sites for repetitive exposure of anadromous salmonids to C. columnaris.

INTRODUCTION

Mortalities in salmonid populations induced by Chondrococcus columnaris

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are usually associated with warm river water temperatures (Fish, 1948; Pascha, 1961; Colgrove and Wood, 1966). Increasing use of the Columbia River for agriculture, industry and power will introduce additional added heat increments which could result in additional growth of C. columnaris and proliferation of the disease. It is necessary, therefore, that we examine the existing environmental factors which contribute to the disease in the river.

Proliferation and release of C. columnaris from fish ladders was demonstrated by the large number of organisms isolated from the Rocky Reach fish ladder on the Columbia River during 1965 (Pauley, et al., 1966). The authors found that C. columnaris release into the water was related to the high incidence of infected coarse fishes and anadromous salmonids in the ladder. In this report, we will describe results which suggest that fish ladders may be important sites for transferring the disease from fish indigenous to the Columbia River to migrating anadromous salmonids.

MATERIALS AND METHODS

Monthly samples of surface water were obtained in the forebay behind the dams, in the top (inlet) and bottom (outlet) of fish ladders, and downstream from the dams. Fifteen separate one gallon samples were drawn from each ladder and river location and four 0.25 ml aliquots from each gallon were surface plated on solid growth medium. The growth medium was composed of 0.4% Bacto-tryptone, 0.04% Bacto-yeast extract

and 1% Nobel agar at pH 7.3. Plates were incubated at 22 to 25 °C for 48 hr prior to counting.

Scraping from gills and/or necrotic areas, if present, and scrapings from the kidney were related to determine degree of exposure or infection in fish populations. To differentiate between exposure or infection of fishes, the following arbitrary definitions were used: 1 to 10 C. columnaris external isolates were designated as an exposure and more than 10 external isolates or 1 or more internal isolates, as an infection. A standard agglutination test of fish sera was used as an additional technique to identify prior or recent infection and the magnitude of antibody production. Blood sera for agglutination studies were taken using dorsal aorta punctures (Schiffman, 1959).

RESULTS

The seasonal variation in the proliferation and release of C. columnaris from fish ladders is illustrated in Table 1. Monthly water samples from the forebay, several hundred feet upstream from the fish ladders, were consistently negative. Since no organisms could be isolated from the forebay water, the organisms found near the ladder inlets were probably released from fish in the uppermost part of the ladder. The values obtained at the ladder outlets represent a total release of organisms from both transient and resident fishes. Water samples one mile downstream were consistently negative, regardless of month, indicating a substantial dilution of organisms in the mainstream.

No organisms were isolated from either end of the Bonneville ladder during the winter months following de-watering of the ladder, when population density of fishes was minimal and water temperatures were below 11.7 °C. Increased temperatures and a noticeable increase in population density of fishes, starting in May, as noted by daily fish counts (U.S. Army Engineers Annual Fish Passage Report, 1966), corresponded with increased releases of C. columnaris.

Evidence for C. columnaris exposure and infection among fishes in ladders was further demonstrated by comparing largescale suckers (Catostomus macrocheilus) from the North Shore Bonneville ladder and from a sampling site several miles downstream from the dam. The results of this study are summarized in Table II. The higher C. columnaris antibody titers and larger incidence of exposure and infection in largescale suckers obtained from the ladder suggest that many of these fish reside in the ladder for extended periods. The data also illustrate the relationship between antibody titer and the incidence of C. columnaris infection.

If the interpretation of these results are correct, a serious C. columnaris infection problem could result from the passage of anadromous salmonids through ladder facilities with heavy concentrations of infected fishes. This suggestion is consistent with the results shown in Table III. Coho salmon (Oncorhynchus kisutch) were sampled for disease during passage through the north shore Bonneville fish ladder, the Priest Rapids ladder, 200 miles and 3 dams upstream from Bonneville Dam and at the Rocky Reach ladder, 70 miles and 2 dams above Priest Rapids Dam, on the Columbia River.

These fish were sampled at intervals of 8 and 21 days, respectively, after passage through the Bonneville ladder, and thus may very roughly represent the same cohort of migrating fish. The experiment was designed to determine whether an increase in incidence of C. columnaris infection and antibody synthesis will occur during migration through fish ladders contaminated with high concentrations of organisms. Definite increases in infection and titer magnitude were observed for the salmon during upstream migration.

Some species of adult anadromous salmonids entering the Columbia River had low levels of C. columnaris antibodies, probably a residual titer from infection as juveniles (Fujihara, 1970). Although the disease is endemic in lower Columbia River coarse fishes, infected adult salmonids have not been observed until the fish reached Bonneville. The implication is that major infection and subsequent antibody synthesis occurs as a result of exposure to infected fish in the fish ladders.

DISCUSSION

The narrow physical confines of fish ladders through which anadromous salmonids must pass during the warm water months of the year make these sites a suspect area for C. columnaris exposure and infection. The fact that Columbia River water, other than from fish ladders, has been consistently negative for C. columnaris, makes it unlikely that a major infection will occur in the normally flowing portions of the river.

High rates of C. columnaris release in fish ladders, measured between June and September, occur at periods when fish occupancy in, and passage through, ladders was greatest. Since a single immune carrier yearling rainbow trout (Salmo gairdneri) can release up to 1×10^7 organisms per hour under laboratory conditions (Fujihara, et al., 1964), and since crowded conditions are known to enhance disease problems (Pascha, 1961), the release of large numbers of organisms by fishes in ladders is a reasonable interpretation of our data. Although the migrant salmon may move rapidly through areas of high C. columnaris density, the presence of such unusual concentrations may be sufficient for infection to occur.

The release of large numbers of C. columnaris is not a problem unique to fish ladders. The investigations of Colgrove and Wood (1966) estimated releases of C. columnaris organisms from the Horsefly River in the Fraser River system in Canada of nearly 3×10^9 cells per second. High temperatures on the spawning ground were believed to have been the major cause of this condition, although a heavy population density of sockeye salmon must have been a contributing cause. Similar calculations show releases of 1.7×10^6 to 3.3×10^8 C. columnaris cells per second from the Columbia River fish ladders.

The immune status of these salmon which develop moderately high agglutinating antibodies against C. columnaris disease during migration is not known and would be difficult to evaluate. Our laboratory studies, however, showed that juvenile coho salmon orally vaccinated against C.

columnaris developed average agglutinating titers of 1:168 and were immune to the disease (Fujihara, 1970). It is conceivable that repeated exposure of migrating salmonids to C. columnaris may have some indirect benefit. Challenges to the disease at successive ladder facilities may induce antibody synthesis sufficient to protect the salmonids during migration.

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TABLE 1. Distribution of C. columnaris release in monthly water samples
at Bonneville, McNary, Priest Rapids and Rocky Reach fish ladders, 1966.

Ladder	Sampling Date	River Temp., °C	Forebay, Isolates/ml	Ladder Inlet, Isolates/ml	Ladder Outlet, Isolates/ml	Downstream from Ladder, Isolates/ml
Bonneville	1/23-3/16	4.0-6.7	0	0	0	0
	4/26	11.7	0	0	0	0
	5/18	12.2	0	0	0.06	0
	6/16	13.9	0	0	0.40	0
	7/16	17.8	0	0.20	0.53	0
	8/24	18.9	0	0	0.47	0
	9/27	18.9	0	0.20	1.47	0
	10/24	13.3	0	0.70	0.67	0
McNary	4/29	10.5	0	0	0	0
	6/18	14.4	0	0	0.13	0
	7/28	17.8	0	0.40	1.47	0
	8/25	19.4	0	0.06	1.07	0
	9/29	21.1	0	0.47	1.80	0
	10/29	13.3	0	0.06	0.47	0
Priest Rapids	7/13	15.0	0	0.67	4.13	0
	8/4	16.1	0	0.13	1.60	0
	9/17	16.7	0	0	1.80	0
	10/15	16.7	0	0	0.67	0
	11/5	11.1	0	0	0.20	0
Rocky Reach	10/8	15.3	0	0	1.0	0
	11/14	11.7	0	0.13	0.27	0

TABLE 2. Difference in C. columnaris exposure, infection and antibody synthesis in largescale suckers from the North Shore Bonneville fish ladder and from a sampling site several miles downstream

	Sampling Date	Temp., °C	No. Fish Sampled	% Exposed* (not infected)	% Infected**	Av. Titer
N. Bonneville Ladder	9/27/66	18.9	20	55	40	1:500
Downstream Site	9/28	18.5	40	35	5	1:200

* 1-10 C. columnaris external isolates/fish

** > 10 C. columnaris external isolates/fish or 1 or more C. columnaris internal isolate/fish

TABLE 3. C. columnaris infection and antibody development during upstream migration of Coho Salmon

Fish Ladder	Temp. °C	Sampling Date	No. Fish	% Infected*	Av. Titers
Bonneville	18.9	9/27/66	22	5	1.38
Priest Rapids	16.7	10/5	20	20	1:61
Rocky Reach	15.3	10/18	20	45	1:232

* >10 external isolates/fish or 1 or more internal isolates/fish

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