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Effect of Parasitism by Mussel Glochidia on Growth of Coho Salmon

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Abstract

Coho salmon fry *Oncorhynchus kisutch*, experimentally infested with glochidia of the freshwater mussel *Anodonta oregonensis*, were reared in the laboratory for 120 days after emergence. Fish with more than 50 glochidia died within the first 30 days. Fish with 50 or fewer glochidia had reduced growth: by 90 days, for example, fish with 1–20 glochidia were only half as large as the controls. Parasitized fish also had reduced fat content. A lake containing freshwater mussels might have smaller coho salmon, which would overwinter an additional year with an attendant reduction in survival.

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Glochidia of the freshwater mussel *Anodonta oregonensis* Lea are common temporary obligate parasites on the fins of salmon, *Oncorhynchus* spp., and sticklebacks (Gasterosteidae) in Alaskan lakes. Infested fish carry these parasites from May until late August when the glochidia develop into juvenile mussels and drop off the fish. The time that glochidia are released from snails coincides with the time that coho salmon *O. kisutch* emerge from gravel. Coho salmon fry become infested with glochidia of *Anodonta oregonensis* during the first 3 months that the fry are feeding. The stress of parasitism during this period of early feeding could cause these fish to be smaller than uninfested fish. Small fry could remain an additional winter in fresh water and thus would have reduced survival. Furthermore, parasitized fish would be more sensitive to pollutants, such as crude oil, than unparasitized fish (Moles 1980).

Other parasites reduce the growth of salmonids. Sockeye salmon *O. nerka* infested with *Eubothrium salvelini* and rainbow trout *Salmo gairdneri* infested with the nematode *Truttaedacnitis truttae* have reduced growth and swimming performance (Boyce 1979; Russell 1980). The nematode *Bulbodacnitis ampullastoma* reduces the food-conversion efficiency of rainbow trout (Hiscox and Brocksen 1973).

This study describes the effects of parasitism by *A. oregonensis* glochidia on growth, survival, and percent fat of coho salmon fry. Hatchery-reared fry of uniform size were experimentally infested with glochidia and compared at 30-day intervals with uninfested fry maintained under similar conditions.

Methods

About 2,200 coho salmon fry were held for 2 days after they emerged from gravel to acclimate them to feeding on Oregon Moist Pellet.[1] After the fry were feeding, they were experimentally infested with glochidia that had been dissected from female mussels (Moles 1980). The level of infestation was controlled by varying the density of glochidia suspended in the water during the attachment process (Moles 1980). A number of densities were used so that the fish were parasitized with 1–100 glochidia per fish. Three hundred of the fish (controls) were put through the same procedure of infestation as the experimental fish except no glochidia were in the attachment container (that is, the fish were sham-infested). Subsequently, experimental and control fish were reared together in a 600-liter tank. Water flow in the tank was 2 liters/minute, and oxygen concentrations were greater than 90% saturation. Fry were fed to excess six times daily. Satiation-feeding provided equal feeding opportunity regardless of parasitism, dominance, or size of the fish (Boyce 1979). Water temperature increased from 4.5 C at day 0 to 6 C at day 90. On day 30, water in the tank was reduced to 300 liters

[1] Reference to trade name does not imply endorsement by the National Marine Fisheries Service.

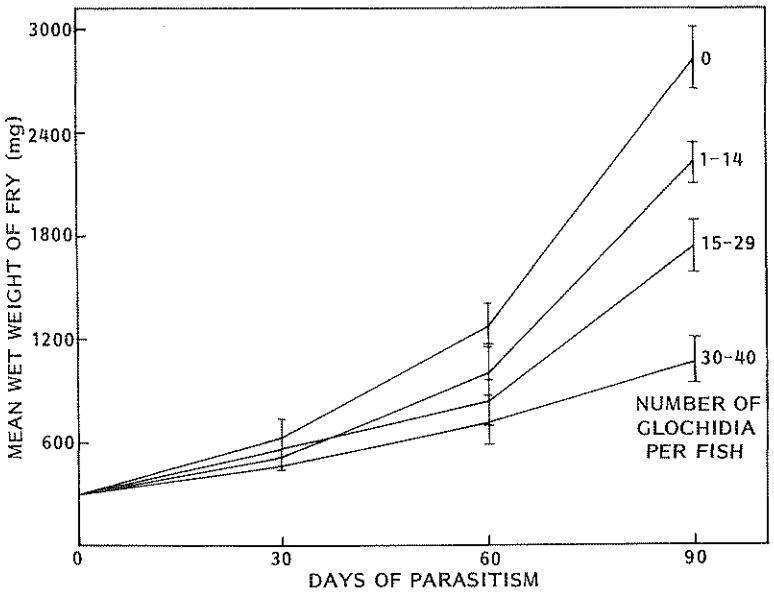

FIGURE 1.—*Mean wet weight of coho salmon fry infested with* Anodonta oregonensis *glochidia for 30, 60, and 90 days (95% confidence limits bracket the means). N = 30 for each data point.*

(1-liter/minute flow) because half of the fish had died. Dead fish were removed daily, and glochidia on their fins were counted.

At 30, 60, and 90 days after infestation, 150 fish were killed and preserved in 5% buffered formalin, and the glochidia on each fish were counted. Ninety days were chosen as the end point of the sampling because none of the glochidia had metamorphosed and dropped off the fish. The greatest number of glochidia metamorphosed on day 105. By day 120, all glochidia had dropped off the fish. Too few fish with more than 40 parasites lived to constitute an adequate sample, so these fish were eliminated from the statistical analysis.

The preserved fry were ordered according to the number of glochidia on the fins of each. I then chose 30 fish from the group with 1–14 glochidia such that about two fish had the same number of parasites and that the mean number of parasites on the fish, as a group, was similar to the median. Thirty fish were chosen similarly from groups with 15–29 glochidia per fish and 30–40 glochidia per fish. Thirty fish that had no parasites were randomly selected for controls. The preserved fish then were weighed, each group of 30 fish was dried in an oven at 64 C for 2 days, and the fat for the pooled group was extracted by dissolving the fish in MF-Freon (Korn and Macedo 1973).

Results

Whether or not parasitism by *Anodonta oregonensis* glochidia was lethal depended on how long and how heavily the fry were infested. Only five parasitized fish died during the first 10 days. After 30 days, however, all of the fish parasitized with more than 50 glochidia (1,030 fish) and most of the fish with 40–50 parasites had died. However, only two fish with fewer than 40 parasites had died. No parasitized fish died after 44 days. All control fish survived.

As the experiment progressed, differences in the growth of fish in the different groups became more apparent (Fig. 1). By day 60, infested fish weighed significantly less than control fish (t-test; $P < 0.05$). By 90 days, the mean wet weights of the three groups were significantly different from the controls and from each other (Fig. 1), and a linear inverse relationship existed between the number of glochidia on a fish and the wet weight of the fish (Fig. 2).

By day 90, the few fish with 41–50 parasites each had not grown at all. Mean weight of other groups were: 30–40 parasites, 1.063 g; 15–29 parasites, 1.748 g; 1–14 parasites, 2.211 g; and

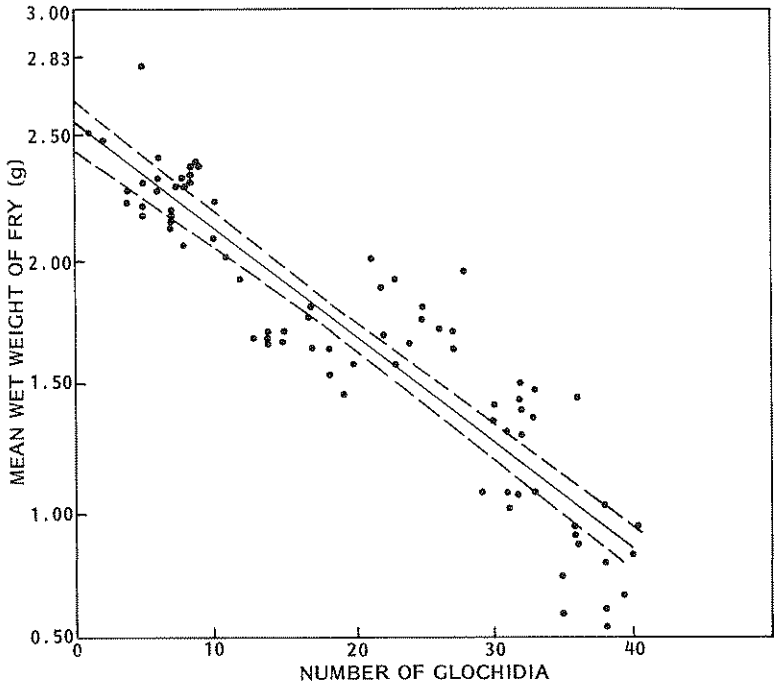

FIGURE 2.—*Linear regression of individual wet weights of coho salmon fry as a function of the number of* Anodonta oregonensis *glochidia on the fry after 90 days of infestation. Broken lines are 95% confidence limits.*

controls, 2.843 g. Parasitized fry had less fat than control fry, and fat content declined as parasite load increased (Table 1). As a result of parasitism, fry were not only smaller but also had lower fat reserves.

Discussion

Parasitism by *Anodonta oregonensis* glochidia reduced growth of coho salmon fry regardless of the number of parasites on the fish. Even fish with only a few glochidia were smaller than the control fry. Parasitized fish and the controls were treated identically; therefore, glochidiosis was the only treatment that affected growth.

TABLE 1.—*Percentages of dry body weight as extractable fat in coho salmon fry with various parasite burdens.*

Number of parasites per fish	Days of infestation			
	0	30	60	90
0	6.1	7.2	17.5	21.3
1–20	6.3	8.1	14.1	20.3
21–40	6.2	6.9	12.4	15.5
40–50	6.0	6.4	8.9	10.2

Anodonta oregonensis glochidia remove nutrients from their host's blood, digest tissue at the site of attachment, and interfere with swimming (Arey 1932). Glochidia reared in vitro require dextrose, amino acids, phosphates, and five salts to complete metamorphosis (Ellis and Ellis 1926), and, in vivo, these nutrients probably are removed from the host's blood. Wound repair takes only 1 or 2 days, so destruction of tissue at attachment sites may not be physiologically debilitating; however, at the onset of parasitism, initial destruction of tissue may contribute to reduced growth. Increased weight of glochidia on the fins requires fry to expend more energy in movement, leading to a lower fat content.

Parasitism by *A. oregonensis* glochidia also could reduce growth of wild coho salmon fry. From 3 to 35 glochidia were found on wild coho salmon fry, and wild fry with 15 or more glochidia on their fins weighed less than their uninfested counterparts. Coho salmon fry with 40 or more glochidia have not been reported for a wild population, possibly because the fish had died of parasitism. More rigorous field studies

are needed to describe the effects of glochidiosis on wild fry.

In lakes, large populations of *Anodonta* spp. may reduce populations of coho salmon. If fry are heavily parasitized with glochidia, many would die initially. If fry survived the infestation, they would be smaller than uninfested fish. Smaller fish are probably more susceptible to predation than larger fish (Bams 1967; Parker 1971). Furthermore, small coho salmon may need to overwinter an additional year in fresh water and compete with newly emerged fry for food, further reducing survival of the population.

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