The Efficacy of Orally Administered Ivermectin for the Control of the Salmon Louse *Lepeophtheirus salmonis*, its Toxicological and Pathological Effects in Atlantic, Chinook, and Coho Salmon, and a Review of its Tissue Residue Times and its Effects on Non-target Marine Organisms

Ivermectin administered orally at a dosage level of 0.05 mg/kg fish twice weekly has been reported to be non-toxic and effective in controlling sea lice on salmon (Jackson and Costello 1992; Smith et al. 1993). The purpose of this Aquaculture Update is to report on our laboratory investigations on the efficacy of ivermectin against the common salmon louse *Lepeophtheirus salmonis*, and its toxicity to Atlantic, chinook, and coho salmon. We also provide a summary of published information on the tissue residue times and the effects of ivermectin on non-target marine organisms. A full report of our investigations on its efficacy against the salmon louse and toxicity to salmon and trout are given in Johnson and Margolis (1993) and Johnson et al. (1993).

In our study, both 3 or 6 doses of ivermectin at a targeted dose of 0.05 mg/kg fish administered in the feed every third day arrested the development and reduced the intensity of infection by *L. salmonis* on Atlantic salmon (Figures 1 and 2). This is the first report of an efficacious treatment against the chalimus stages of sea lice. Serious head and dorsal body lesions, typical of *L. salmonis* feeding activity, developed on the control fish during this study but were absent from the ivermectin-treated fish. Ivermectin fed at these dosages resulted in a darkening of the fish but appeared not to reduce their feeding activity.

We also investigated the toxicity and pathological effects of various doses of ivermectin administered orally every second day to coho, chinook, and Atlantic salmon under laboratory conditions (Table 1). These species differed in their ability to tolerate ivermectin, with coho salmon the most tolerant followed by chinook, then Atlantic salmon.

**Atlantic Salmon**

Ivermectin fed to Atlantic salmon at rates of 0.05 mg/kg and 1.0 mg/kg every second day for 50 days resulted in cumulative mortality of 10 and 14%, respectively, over the 65 days of the study. Cumulative mortalities in excess of 80% occurred at higher doses, with fish showing toxic effects (loss of equilibrium) after 1 dose in the 0.50 and 1.0 mg/kg treatment groups and after 3 doses in the 0.20 mg/kg treatment group. All fish in these groups darkened in colour, and the eyes of the moribund and surviving fish were rolled ventrally so that the lenses were no longer visible. Fish in the 0.05 mg/kg treatment group showed a reduction in their feeding activity.
activity, some loss of equilibrium, and a darkened colour after 6 doses of ivermectin (12 days).

Chinook salmon

No mortalities occurred in the control or 0.05 mg/kg treatment groups (Table 1). A 10 % cumulative mortality occurred in the 0.10 mg/kg treatment group. All treatment groups consumed their full treated food ration throughout the experiment. A reduction in the feeding activity was noted after 13 doses in both ivermectin-treated groups. At the end of the experiment the 0.10 mg/kg group was darker in colour and was feeding much more slowly than the 0.05 mg/kg treatment group.

Coho salmon

The coho control group had an 8 % cumulative mortality over the experimental period (Table 1). No mortalities occurred in the 0.05 mg/kg treatment group, and there was only a 2 % cumulative mortality in the 0.10 mg/kg treatment group. In the 0.20 mg/kg treatment group there was a 20 % cumulative mortality at the end of the experiment. Although feeding activity was reduced when compared to the controls, full treated feed rations were eaten in the 0.05 and 0.10 mg/kg treatment groups throughout the experiment. A reduction in the feeding activity of the 0.20 mg/kg treatment group was noted after 5 doses of ivermectin (day 11).

Histology

Histological examination of the major organ systems of all three salmon species revealed no pathological changes that could be associated with ivermectin toxicity.

Tissue Residue Times

A major drawback with the use of ivermectin is its long tissue withdrawal time. Jackson and Costello (1992) reported a tissue withdrawal time of 700 degree days and noted that this limits its use to treatment of infections in smolts. Roth et al. (1994) reported that Atlantic salmon fed ivermectin at a rate of 0.05 mg/kg weekly for nine weeks would require a minimum withdrawal period of 1000° days (67 days at 15° C to 200 days at 5° C) to eliminate ivermectin from the edible tissues.

Effects on Non-Target Marine Organisms

It is expected that a relatively high proportion of ivermectin fed to fish will enter the marine environment via uneaten feed and fecal material (see Høy et al. 1990). Burridge and Haya (1993) recently reported on the toxicity of water-borne and feed-associated ivermectin to the marine shrimp *Crangon septemspinosa*. Exposure to ivermectin in water (maximum concentration of 0.2 mg/L) appeared not to have any effects on the shrimp. However, ivermectin when presented in the feed was highly toxic to the shrimp with 24-hour LC50 values ranging between 0.08 and 0.18 mg/g food.
Although ivermectin has been demonstrated to be an effective therapeutant for the control of sea lice, recent studies indicate that it is toxic to non-target organisms. For this reason we anticipate that there may be difficulties in obtaining regulatory approval for the use of ivermectin in aquaculture. Furthermore, its long tissue withdrawal time would limit its usefulness as a therapeutant for fish close to harvest.

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References


Table 1. Toxicity of orally administered ivermectin to salmon and trout. (Fish were fed a commercial diet sprayed with ivermectin in the form of a veterinary preparation of 1% w/v oral drench every second day for 50 days.) With exception of the Atlantic salmon 0.20, 0.50, and 1.0 mg/kg treatment groups, which were monitored for only 27 days, mortalities in the coho and chinook salmon were monitored for 64 days.

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<tr>
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<th>Cumulative Mortality (%) at various doses</th>
<th>Control</th>
<th>0.05 mg/kg</th>
<th>0.1 mg/kg</th>
<th>0.2 mg/kg</th>
<th>0.5 mg/kg</th>
<th>1.0 mg/kg</th>
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<tr>
<td>Atlantic salmon</td>
<td></td>
<td>0</td>
<td>10</td>
<td>14</td>
<td>80</td>
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<td>90</td>
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<td>Coho salmon</td>
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<td>8</td>
<td>0</td>
<td>2</td>
<td>20</td>
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<td>Chinook salmon</td>
<td></td>
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Fig. 1. Mean (+SD) number of *Lepeophtheirus salmonis* on control and ivermectin-treated Atlantic salmon in two trials. Fish were fed either 3 or 6 doses of ivermectin at a targeted level of 0.05 mg/kg every third day. Fish were maintained at 11.0 to 13.3 °C and ambient salinity (29 to 31 %). An * above error bars indicates significant differences in numbers (T-test; P<0.05).

Fig. 2. *Lepeophtheirus salmonis* stage distributions on control and ivermectin-treated Atlantic salmon in two trials. Fish were fed either 3 or 6 doses of ivermectin at a targeted level of 0.05 mg/kg every third day. 2A: trial 1 samples collected 1 week after the third dose (day 14). 2B: trial 1 samples collected 1 week after the sixth dose (day 21). 2C: trial 2 samples collected 1 week after the sixth dose (Day 21). Fish were maintained at 11.0 to 13.3 °C and ambient salinity (29 to 31 %). (Ch3, third chalimus; Ch4, fourth chalimus; P1M, first preadult male; P1F, first preadult female; P2M, second preadult male; P2F, second preadult female; M, adult male; F, adult female).