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ScienceDirect

Aquaculture 260 (2006) 163–180

Aquaculture

www.elsevier.com/locate/aqua-online

Environmental effects of the anti-sea lice (Copepoda: Caligidae) therapeutant emamectin benzoate under commercial use conditions in the marine environment

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Received 27 October 2003; received in revised form 1 June 2006; accepted 7 June 2006

Abstract

Sea lice infestation can pose a particular problem to intensive cage aquaculture of salmonids. It is most often treated by therapeutants added to the water or incorporated into fish feed. This study investigated the environmental effects of one such in-feed treatment, emamectin benzoate, under commercial use conditions. Atlantic salmon were fed the commercial preparation of emamectin benzoate at a production fish farm on the west coast of Scotland. Sediment dwelling fauna, large mobile fauna and sentinel organisms were monitored for potential impacts over a 1 year post-treatment period (23 September 1997 to 23 September 1998). Additionally, sediment and water samples, transplanted blue mussels and captured large fauna were analysed for accumulated emamectin benzoate and its desmethylamino metabolite to investigate the long term environmental fate of emamectin benzoate.

Results from analysis of sediments suggested that limited deposition of emamectin benzoate took place during and up to 1 week post-treatment, and may have continued up to 4 months of post-treatment. This was consistent with the release of the active ingredient from fish excretion and defecation after treatment. Quantifiable amounts of emamectin benzoate were found 10 m from the cages 12 months after treatment. However, clear reduction in overall sediment concentrations indicated that the deposited emamectin was degrading over time. Emamectin benzoate was not detected in water samples during the field trial. Quantifiable concentrations of emamectin benzoate were found in blue mussels deployed up to 100 m from the treatment cages at 1 week post treatment, but found only at 10 m from the cages at 1 month post-treatment. This suggests that while mussels were actively accumulating emamectin benzoate immediately after treatment by 1 month this had largely been depurated.

Macrobenthic faunal analysis indicated that there was no evidence that the occurrence of emamectin benzoate, or its desmethylamino metabolite, in sediments around fish farm cages after treatment had any toxic impacts on organisms in either water column or sediments.

Keywords: Emamectin benzoate; Environmental impact; Sediment quality; Salmon farming

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0044-8486/$ - see front matter
doi:10.1016/j.aquaculture.2006.06.024

1. Introduction

Chemotherapeutant treatments are used to control infestations of sea lice in commercial salmon farms (Roth et al., 1993). Several treatments are available, mostly employing immersion bath treatments of hydrogen peroxide (Treasurer and Grant, 1997) organophosphates or pyrethroids. Following the treatment period, these therapeutants are released into the marine environment and initially become dispersed throughout the water column. These treatments are labour intensive, costly and may cause considerable stress to the fish (Pike and Wadsworth, 1999). In addition, their use may be limited by the physical environment or weather conditions, and resistance among some populations of the parasite has been a consequence of the widespread use of a small number of active agents (Jones et al., 1992). In-feed therapeutants, as their name suggests, adopt the more targeted approach of being incorporated into the fish feed, enabling medication during adverse weather conditions and allowing simultaneous medication of several fish cage sites (Stone et al., 1999). These treatments are released to the environment largely in particulate form via uneaten feed, faecal material and in soluble form in urine. Therefore both water column and seabed potentially receive inputs of active ingredients and metabolite from such treatments.

The therapeutant emamectin benzoate (4″-epimethylamino-4″-deoxyavermectin B_1 benzoate) has been used in the control of arthropod pests, such as insects of food crop vegetables (Jannson and Dybas, 1998). It is known to be highly effective and can be used in low quantities within treatments. More recently the substance has proved to be highly effective as a treatment against infestation of the sea lice *Lepeophtheirus salmonis* on Atlantic salmon within cage farms in Scotland (Stone et al., 1999, 2000a), Norway (Ramstad et al., 2002) and Canada (Armstrong et al., 2000). It is incorporated as a veterinary medicinal premix into pelleted food for administration to the fish, and is authorized under the trade name SLICE® (Schering Plough Animal Health, Union, USA). In-feed treatments have the advantage of being able to deliver the chemotherapeutant to the site of action while minimizing losses to the environment. In Scotland, the availability of SLICE has enabled farmers to effectively eliminate lice from salmon farms for periods of 12–18 weeks following treatments (Treasurer et al., 2002; Dear and Wallace, 2002).

Emamectin benzoate has a low water solubility (5.5 mg/L) and moderate to high octanol–water partition coefficient ($\log K_{ow}=5.0$ at pH 7.0) (Schering-Plough Animal Health, 2002), suggesting that material released to the aquatic environment is likely to be rapidly bound to particulate material or surfaces. Thus the potential impacts of this treatment could be predicted to be asociated with sediment dwellers or fauna which feed on suspended particulate material, such as filter feeders. Potential impacts on these two groups are addressed in the present study.

The aim of the present study was to monitor the fate and environmental effects of emamectin benzoate after a treatment administered over a 7-day period at a fish farm site under commercial use conditions. Localised dispersion was investigated by measuring concentrations of emamectin benzoate and the desmethylamino metabolite (4″-epiamino-4″-avermectin B_1 benzoate) within sediments and surface flocculent material. Environmental impacts were investigated within three ecosystem components: (i) sediment infaunal communities, (ii) water-column filter feeders and (iii) surface dwelling crustaceans and molluscs.

The study was undertaken at an Atlantic salmon commercial production site in the north–west of Scotland and was subject to independent auditing to ensure compliance with the principles of Good Laboratory Practice. The site had twenty-four 15 m square steel cages, twelve of which were treated with emamectin benzoate. The farm was in routine commercial production during the experimental period.

2. Methods

2.1. Treatment regimen for emamectin benzoate

The treatment regimen for this study was designed to administer anti-parasite treatment at a rate of 50 μg active ingredient (a.i.) per kg fish biomass per day over 7 days (17–23 September 1997). This has been shown to be effective against lice with no adverse effects on the treated salmon (Stone et al., 1999; Roy et al., 2000). Subsequent analysis of the treated feed found that the active ingredient in feed, taken from the treatment batch, averaged 4.36 mg a.i./kg feed, which was 87.2% of the nominal value of 5 mg a.i./kg feed. The active ingredient was administered as a formulated premix in oil-coated feed.

Twelve commercial cages (each 15 m × 15 m × 15 m), from a total of 24 stocked cages in a 30-cage pontoon, were treated with emamectin benzoate in fish feed at a dose rate of 50 μg a.i./kg fish biomass per day, for a period of 7 days. The remaining cages received a normal ration of unmedicated feed. Feeding, during the treatment period was by hand to ensure careful placement and use of the medicated food. After treatment, and for