Control of sea lice on farmed Atlantic salmon *S. salar* L. with the oral treatment Emamectin benzoate (SLICE)

Treasurer J.W.1*, Wallace, C1 and Dear, G.2

1Marine Harvest Scotland, Lochailort, Inverness-shire PH38 4LZ*, 2Marine Harvest Scotland, Craigcrook Castle, Edinburgh EH5 3LP, United Kingdom

Abstract

The use of orally administered emamectin benzoate (SLICE) to control sea lice was assessed for all stock on two salmon farms. Contrasting treatment regimes were used with two oral treatments in farm E in the second production year and one oral treatment in farm L with follow up with bath treatments. Emamectin benzoate surface coated on feed was administered as 50 ug kg⁻¹ fish biomass day⁻¹ over 7 days. Lice numbers on farm E declined to zero over 3 weeks and further chalimus settlement was suppressed with a level of zero lice attained over a 14 week period. When lice numbers increased a second oral treatment achieved <1 louse per fish until the farm was fallowed at the end of the second year. The second farm treatment with emamectin benzoate achieved zero lice levels for 12 weeks but later lice settlement was treated by bath medicines and several repeat treatments were required.

Introduction

Sea lice (*Copepoda: Caligidae*) continue to be an important health issue of farmed Atlantic salmon *Salmo salar* L. Interventionary regimes include licensed sea lice medicines tested for environmental safety with discharge authorisation from SEPA in Scotland. From 1993 to 1998 sea lice treatments in Scotland were mainly applied as a bath using hydrogen peroxide (Salartec, Solvay Interox) and dichlorvos (Aquagard, Novartis) (withdrawn from use in 1998), and subsequently azamethiphos (Salmosan, Novartis) and cypermethrin (Excis, Novartis). Sea lice numbers are monitored to determine optimal treatment time (Treasurer & Pope, 2000), often to coordinate management agreements between farms and companies in a hydrographic area (Grant & Treasurer, 1993) and synchronous treatments are used as part of a National Sea Lice Treatment Strategy in Scotland (Wadsworth et al., 1998; Rae, 2002). Bath treatments have disadvantages (Costello, 1993): they generally only affect the mobile lice stages, treatments may be less effective due to variable enclosed volumes and fish may be stressed during crowding. Cypermethrin may affect the immune response and make fish less resistant to infection (Wadsworth, 1999).

Sea lice medicines have been used orally on a commercial scale in Scotland since 2000, such as the moult inhibitor teflubenzuron (Calicide, Trouw) (Branson et al., 2000) and emamectin benzoate (SLICE, Schering-Plough) (Stone et al., 1999a, 2000a). These are surface coated on the feed as 10 mg kg⁻¹ body W d⁻¹ for Calicide
and 50ug kg⁻¹ biomass d⁻¹ for SLICE for a period of 7 days. Although used extensively in Norway and Chile oral treatments have only been used on a larger scale in Scotland from spring 2001 (Rae, 2002). In tank trials Stone et al. (2000a) defined the safety of the product and effective treatment dose and residue times. Small scale field trials on Atlantic salmon farms (Stone et al., 2000b) and later full scale treatment of selected cages (Stone et al., 2000c) showed that emamectin benzoate was effective against all stages of sea lice and protection against resettlement continued for up to 69 days. However, the use of oral treatments to control sea lice on an entire farm stock over a two year production cycle has not been examined. The present study examines the use of emamectin benzoate in two applications in spring of the second production year and compares this regime with that in a nearby farm where there was only one use and subsequent treatments were by standard bath treatment. The regime coincided with normal implementation of the National Sea Lice Treatment Strategy in Scotland (Rae, 2002). The value of emamectin benzoate in controlling sea lice in the spring when wild salmonids are known to migrate from river systems (Butler, 2002) is discussed. The value of oral treatments is also compared with bath treatments and the best use and timing of such treatments is examined.

**Methods**

Emamectin benzoate (SLICE) was used for sea lice intervention and treatment on two salmon farms, 25 km separation, in the same sea loch in Lochaber, west Scotland. Sea loch characteristics were a typical fjord shape being 35 km long with an average width of 2 km, a mean depth of 30 m at farm E and 42 m at farm L, and both with a flushing time of 5 days. Mean surface current speeds were 5 cm sec⁻¹ at farm E and at 7 cm sec⁻¹ at farm L. Mean water temperature range was 8 to 15°C on both farms and salinity range 15 to 32 ppt on farm E and 26 to 33 ppt in farm L. There was a total of 500,000 fish on each farm with stocking densities from 12 to 20 kg m⁻³. Fish weight increased from 1.4 kg at the beginning of the second year of the production cycle to a mean of 4.7 kg in week 43.

Numbers of lice were counted weekly on 30 fish from each farm, with 5 fish removed by handnet during feeding from each of 6 cages following the protocol described by Treasurer and Pope (2000). The fish were anaesthetised in 15 ppm benzocaine and stages of lice recorded as gravid (ovigerous female), adult females, adult males, pre-adults combined I and II and both sexes, chalimus I-IV, and *Caligus elongatus* mobiles. Data presented refer to *L. salmonis* as there were only small numbers of *Caligus* recorded seasonally, normally in the range 2 to 5 per fish. Emamectin benzoate was administered orally as 50ug kg⁻¹ fish biomass day⁻¹ over 7 days surface coated on feed pellets. In bath treatments nets on cages were raised and enclosed with a tarpaulin and administered as either 0.1ppm azamethiphos (=0.2 ppm Salmosan) or cypermethrin (Excis) at 5 ppb concentration for 1 hour duration. Oxygen was supplied to each cage to achieve a level of 7 to 10 mg L⁻¹. Lice numbers were plotted as the mean number of chalimus and mobile stages of all fish sampled on each sampling occasion.
Results
Results are depicted in Figures 1 and 2, only second year of production shown. Numbers of L. salmonis increased in a pattern typical in the last part of the first year (cf Revie et al., 2002) from week 42 to a maximum of 7 lice of all mobile stages per fish on farm E. Although fish were treated successfully with cypermethrin numbers of L. salmonis increased again and fish were treated in week 49 and also in the second year of production in week 4, on both occasions with azamethiphos. The discharge consent for emamectin benzoate was not available until week 9 and fish were treated on week 10. Mobile lice numbers declined immediately followed by a second recruitment to mobile stages moulted from chalimus stages in week 11. There may have been infectious copepodids and nauplii in the water column following treatment and these can be seen in further increases in chalimus numbers in weeks 11 and 15 respectively. However, efficacy of emamectin benzoate persisted as chalimus numbers declined with no moulting to mobile stages. Lice numbers were zero for a 14 week period thereafter before recruitment re-commenced in week 30, rising to a maximum of 13 lice per fish. Fish were given a second oral treatment and subsequently lice numbers declined to negligible levels and remained low until all fish were harvested by December.

Sea lice dynamics on fish in farm L were similar although there was an early rise in numbers of L. salmonis in the first production year to 3 mobiles by August. Lice numbers remained at an average of 1 louse until December when fish were treated for a second time with azamethiphos but with reduced success. Two further treatments with cypermethrin followed, including the first National Strategic Treatment carried out in week 8. The dis-

![Figure 1](image-url)
Charge consent for the oral treatment was received later in farm L and so emamectin benzoate could not be used until week 15. Lice numbers declined to zero over 3 weeks and remained at this level for 12 weeks. As in farm E, lice numbers increased from week 36 to an average of 20 lice per fish but, as there was only a limited discharge consent for one treatment with emamectin benzoate, a bath treatment with cypermethrin was used. Although this treatment was effective there was subsequent lice settlement and two further treatments with cypermethrin were required before all fish were harvested and the farm fallowed in December.

Discussion
The pattern of sea lice dynamics described here is markedly different from the sea lice epidemiology summarised for 33 seawater farms) from 1996 to 2000 by Revie et al. (2002) and also by Bron et al. (1993). In these cases lice numbers increased towards the end of the first year of the production cycle and all interventions were bath treatments. Numbers of lice increased steadily through the second year regardless of therapeutic intervention. Spring 2001 was the first occasion that emamectin benzoate was authorised for use on the farms in this study and the dislocation to the louse population was dramatic with zero lice achieved for 12 to 14 weeks in the two farms respectively. In a tank trial emamectin benzoate was highly effective in reducing lice numbers and also prevented recruitment for c. 10 weeks from the date of treatment (Stone et al., 2000b). Although lice did re-infest the farmed fish again in the second year in the present study this was late in the production cycle. The study demonstrates that a very low louse loading can be achieved on salmon farms using oral sea lice medicines during the period when wild salmonids are
migrating to sea.

The data from farm L also show the requirement for repeat intervention when relying on bath treatments, particularly at the end of the second sea year and so required a higher overall medicinal input. In contrast, one repeat treatment with emamectin benzoate on farm E reduced numbers of lice numbers to < 1 mobile fish until all fish were harvested.

The lack of coordination of oral treatments on farms E and L was due to different dates on which discharge consents were authorised. Maximum impact on sea lice populations can be achieved by treating all farms in a single hydrographic area in a coordinated fashion, and so decreasing the risk of resettlement when the therapeutic effects of emamectin benzoate decline. This practice would achieve a medicinal fallow period in the second spring prior to wild salmonids migrating to sea. In conclusion, this improved sea louse control regime would reduce the requirement for therapeutic intervention and improve the fish welfare and condition and any potential impact on fish growth due to infestation. Bath treatments also have the disadvantage of requiring a starve period prior to treatment and this can affect fish appetite (Costello, 1993).

Guidance is required on the best timing of oral sea louse treatments. The best approach to sea louse control to minimise use of medicines and prevent development of resistance is increasingly recognised as being dependent on an integrated approach (IPM) (Mordue & Pike, 2002). This utilises preventative measures such as fallowing, single year class production, management agreements to enable coordination of treatment, and also biological control where feasible (Pike, 2002). This approach also involves the rotation of medicines to prevent the development of resistance and also requires the optimum use of available medicines, both bath treatments and oral medicines. Understanding of the national and farm level epidemiology of sea lice is a prerequisite for planning a control strategy and national patterns have been described by Revie et al. (2002). Although national sea lice control regimes using bath treatments have been only moderately successful this has been attributed to the lack of effective intervention techniques (Rae, 2002). Providing resistance of lice to in-feed treatments can be minimised, the elimination of lice for 12 to 14 weeks on the farms demonstrated here indicates that the National Sea Lice Treatment Strategy could be enhanced. A clear guideline on use of either bath or oral treatments is required. The use of bath treatments in the first summer, particularly against the second louse species encountered Caligus elongatus, and utilising oral treatments in early spring when fish biomasses are higher would be a starting point.

References


