Preventive Veterinary Medicine 136 (2017) 1–10

Contents lists available at ScienceDirect

Preventive Veterinary Medicine

journal homepage: www.elsevier.com/locate/prevetmed

# Evaluating the effect of synchronized sea lice treatments in Chile

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ARTICLE INFO

*Article history:*
Received 1 June 2016
Received in revised form 14 November 2016
Accepted 21 November 2016

*Keywords:*
Sea lice
Antiparasitic treatment
Treatment coordination
Treatment synchronization
Pyrethroids
Azamethiphos
Atlantic salmon
Chile
Linear mixed models

ABSTRACT

The sea louse is considered an important ectoparasite that affects farmed salmonids around the world. Sea lice control relies heavily on pharmacological treatments in several salmon-producing countries, including Chile. Among options for drug administration, immersion treatments represent the majority of antiparasitic control strategies used in Chile. As a topical procedure, immersion treatments do not induce a long lasting effect; therefore, re-infestation from neighbouring farms may undermine their efficacy. Synchronization of treatments has been proposed as a strategy to improve immersion treatment performance, but it has not been evaluated so far. Using a repeated-measures linear mixed-effect model, we evaluated the impact of treatment synchronization of neighbouring farms (within 10 km seaway distance) on the adult lice mean abundance from weeks 2 to 8 post-treatment on rainbow trout and Atlantic salmon farms in Chile, while controlling for external and internal sources of lice before the treatments, and also for environmental and fish-related variables. Results indicate that treatment synchronization was significantly associated with lower adult lice levels from weeks 5 to 7 after treatment. This relationship appeared to be linear, suggesting that higher levels of synchronization may result in lower adult sea lice levels during these weeks. These findings suggest that synchronization can improve the performance of immersion delousing treatments by keeping sea lice levels low for a longer period of time. Our results may be applicable to other regions of the world where immersion treatments are widely used.



## 1. Introduction

Sea lice are parasitic copepods that affect farmed and wild salmonids in the marine phase and are considered one of the main health challenges for the salmon industry worldwide (Costello, 2006; Burka et al., 2012). In Chile, the sea lice species of concern is *Caligus rogercresseyi*. Heavy infections with other sea lice species have been associated with skin damage (Joínsdoíttir et al., 1992; Nolan et al., 1999), chronic stress and, possibly, increasing susceptibility to secondary infections (Johnson et al., 2004; Revie et al., 2009; González et al., 2015). Infections are thought to increase costs on farms due to reduced fish growth, reduced feed conversion efficiency, administration of chemotherapeutants, and reduced marketability due to skin lesions (Costello, 2009; Liu and Bjelland, 2014).

Globally, the most common tool for controlling sea lice is the use of antiparasitic drugs (Igboeli et al., 2014; Bravo et al., 2015); however, in recent years treatment failures have been reported in most salmon-producing regions (Sevatdal and Horsberg, 2003; Sevatdal et al., 2005; Bravo et al., 2008; Lees et al., 2008; Jones et al., 2012). This situation has motivated investigations of the performance of anti-lice treatments, revealing that one cause of treatment failure is the low sensitivity of sea lice to certain chemicals (Sevatdal and Horsberg, 2003; Sevatdal et al., 2005; Bravo et al., 2008). More recently, research has focused on improving drug administration methods with immersion treatments (i.e. baths) (Corner et al., 2011), which involve complex procedures at the farm.

Sea lice re-infestation from external sources is a factor that can reduce the length of time that treatments are effective for by rapidly increasing the lice levels immediately post-treatment. This may be exacerbated in the case of immersion treatments, which do not provide long lasting residual effects, as do some in-feed treatments such as emamectin benzoate (EMB). Several studies

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http://dx.doi.org/10.1016/j.prevetmed.2016.11.011
0167-5877/

have found that external sources of lice are significantly associated with sea lice abundances at the farm level (Jansen et al., 2012; Aldrin et al., 2013; Kristoffersen et al., 2014). Moreover, a recent study conducted in Chile concluded that the infection pressure from neighbouring farms was greater than that coming from within the farm itself (Kristoffersen et al., 2013). Thus, in the context of immersion sea lice treatments in Chile, external sources of sea lice may seriously limit the duration of the treatment effect associated with these products.

One treatment strategy that addresses external sources of sea lice is coordinated treatments. The rationale behind this approach is to interrupt the sea lice life cycle at all farms at the same time, which should minimize the exchange of copepodids among farms after the treatments and keep the sea lice levels low over time (Ritchie and Boxaspen, 2011). Coordinated sea lice treatments have been implemented in many salmon producing regions around the world (Rae, 1999; Jackson, 2011; Revie, 2011; Ritchie and Boxaspen, 2011; Saksida et al., 2011). In Norway, Ireland, Scotland, and the western coast of Canada, coordinated delousing treatments are performed at specific times of the year (once or twice a year, usually in winter and spring) to reduce gravid sea lice on farms and transmission to out-migrating juvenile wild salmonids in the spring (Rae, 1999; Jackson, 2011; Revie, 2011; Ritchie and Boxaspen, 2011; Saksida et al., 2011). These procedures have been referred to as strategic coordinated treatments, as they target specific lice stages at specific times of the year.

In Chile, coordinated treatments are aimed at improving treatment performance; to that end, treatment coordination is encouraged all year round by establishing coordinated windows of 7 days of duration every 2 weeks (approximate) for each of the eight administrative macro-zones in the country (SERNAPESCA, 2012). Within each macro-zone, salmon farms are grouped into neighbourhoods, in which farms are required to coordinate certain management strategies. Neighbourhoods are delimited by epidemiologic, oceanographic, operational, and geographic criteria by the government authority (Subpesca, 2011). Because treatments in Chile need to be carried out in a relatively short period of time, the term "synchronized" is a better descriptor of the activity than "coordinated". At the time of this study, synchronized treatments in Chile were optional unless the parasite level on a farm surpassed 9 mobile lice per fish. Farms with this level of lice, and neighbouring farms within 5 nautical miles with more than 6 mobile lice per fish, were required to treat within the synchronization window (SERNAPESCA, 2012).

There are no published studies that have evaluated the effect of treatment synchronization on sea lice levels over time. The Chilean context, which involves monthly voluntary synchronized treatments, weekly sea lice monitoring, and a large number of fish farms, offers a unique opportunity to evaluate treatment synchronization at the farm level, while controlling for external sources of lice and factors that affect the sea lice abundance at the farm itself. The objective of this research was to assess the duration of the effect of synchronized treatments on sea lice levels while controlling for the initial treatment effect on farms and other potential confounders.

## 2. Materials and methods

### 2.1. Study location

Our study was conducted in Los Lagos and Aysén regions (41°28′ to 46°18′S) in southern Chile. This area consists of a 500 × 150 km system of small channels, fjords, and islets, which contains approximately 90% of the salmon farming activity in the country. Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) were the most commonly grown species on approximately 70% of the active farms, in 2012–2013, while Coho (*Oncorhynchus kisutch*) and Chinook salmon (*Oncorhynchus tshawytscha*) represented the rest.

### 2.2. Data and study period

Data originated from the Chilean salmon farming association's (SalmonChile) sea lice monitoring program, which collects and manages information on approximately 90% of salmon farms located in the study area. Each participating farm reports *C. rogercresseyi* counts for juvenile (chalimus I–IV), mobile adults (including non-gravid females), and gravid female stages on 10 fish from each of four pens (40 fish in total) on a weekly basis. Weekly sea lice assessments are performed by farmers following the protocols described in the Specific Sanitary Program for Surveillance and Control of Caligidosis (SERNAPESCA, 2012), which is run by the Chilean government. Information about delousing treatments is also reported to SalmonChile's database, specifying the product used and the start/finish dates of the procedure at the farm level. Environmental data, such as water temperature and salinity, and production information, such as number of fish and average fish weight, are also collected on a weekly basis. We restricted the data in our study from January 2012 to September 2013 because of a change in the method of reporting treatments in the database that occurred in late 2011. Farms rearing Coho and Chinook salmon were not included in the analysis because these farms are not required to report lice abundance as frequently as the other species, due to their relative low susceptibility to *C. rogercresseyi* infections (Bravo, 2003; Yatabe et al., 2011).

### 2.3. Selection of treatment events

Treatment events for this study were selected from all immersion treatments reported through SalmonChile's sea lice monitoring program during the study period. Each treatment event was followed in time, either until a new delousing treatment occurred or to a maximum of eight weeks post-treatment. Our study was restricted to treatments performed with the topical drugs azamethiphos and synthetic pyrethroids (deltamethrin and cypermethrin), because these drugs were the most common used in Chile during the study period (R. Ibarra, Intesal-SalmonChile, pers. comm.). Treatments performed with more than one drug were not included in this study because they are not a common practice in Chile and are not promoted by the industry (J. Mancilla, Marine Harvest Chile, pers. comm.). In addition, we included only treatment procedures lasting up to one week, in order to avoid exceptionally long procedures. Finally, we excluded treatment events carried out on farms with no neighbouring farms within 10 km seaway distance, because the treatment synchronization effect could not be assessed if farms did not have neighbours. Delousing treatments were carried out by the farmers based on their own criteria, following the manufacturers' directions.

### 2.4. Study design and outcome variable

The study design was structured as a retrospective cohort study. Our outcome of interest was the adult *C. rogercresseyi* mean abundance at the farm level after a delousing treatment, starting from the second week and up to the eighth week after the procedure. We did not include the first week post-treatment in the outcome because we were not interested in modeling the drop of sea lice levels right after the treatment, given that another study recently addressed this issue on *C. rogercresseyi* (Arriagada et al., 2014). We chose adult *C. rogercresseyi* as the outcome, because this life stage appeared to be more sensitive to synthetic pyrethroids than the juvenile stages (Arriagada et al., 2014), and because both