Control and mitigation of infectious salmon anaemia virus in farmed salmon: protocol for scoping review

Registration:

The protocol will be made available at Systematic Reviews for Animals and Food (SYREAF) (http://www.syreaf.org).

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Amendments:

None to report.

Support: Source, sponsor, and role of funder:

Funding was received from the Atlantic Fisheries Fund (AFF). The funding agency will not influence the design, implementation, analysis of the work, review, or development of the manuscript prior to submission.

Conduct and reporting guidelines:

This protocol was established in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis for Scoping Reviews (PRISMA-ScR) reporting guidelines (Tricco et al. 2018).

Abstract

Background: Infectious salmon anaemia (ISA) is a viral disease of major economic importance in most countries that farm Atlantic salmon. Although clinical ISA outbreaks can result in cumulative mortalities of up to 90%, most surveillance programs focus on early detection of the causative agent, infectious salmon anaemia virus (ISAV), to implement control measures—typically depopulation—to limit viral spread. Despite these measures, ISAV continues to be detected in salmon populations, posing ongoing challenges for producers and policymakers. A comprehensive study is needed to address gaps in the literature regarding ISAV control practices, distinct from existing reviews that primarily focus on detection.

Objectives: The objective of this scoping review is to provide an overview of ISAV control practices in farmed salmon, including reported evidence of their effectiveness.

Eligibility criteria: Analytical studies and review articles published in peer-reviewed journals, available governmental reports, and grey literature detailing different ISAV control practices will be included. Case reports and case series will be excluded.

Sources of evidence: Boolean search will be executed through CAB abstracts (via EBSCO host), PubMed, Scopus and the Earth, Atmospheric & Aquatic Science Collection (via ProQuest) in the same day.

Charting methods: Data charting will include study characteristics, variables related to population of interest (farmed salmon), different control practices and their measures of efficiency.

Conclusion: The findings of this review will offer valuable guidance for fish farmers, researchers, and policymakers to pinpoint the most effective strategies for control and management of ISAV in farmed salmon populations.

1. Introduction

1.1. Rationale

Infectious salmon anaemia virus (ISAV), classified within the family *Orthomyxoviridae* (Kawaoka et al., 2005), is a notifiable pathogen under the World Organisation for Animal Health (OIE) due to its significant economic impact on salmon farming (Mardones et al., 2011). The disease it causes, infectious salmon anaemia (ISA), has been reported in several salmon-producing countries. The first outbreaks of clinical ISA were recorded in Norway in 1984, with subsequent cases documented in Canada, Scotland, the Faroe Islands, Maine (US), and Chile (Christiansen et al., 2021).

At the farm level, ISA is a slowly progressing, systemic disease, usually detected first in a subset of net pens in which daily mortality is typically between 0.05% to 0.1% (Falk, 2014). If the disease goes unchecked, cumulative mortality in a pen or farm could reach 80% - 90% over several months (Rimstad et al., 2011).

Detection of ISAV can result in substantial economic losses for the industry, usually attributed to the removal of exposed stocks, limitations on fish transportation and commerce, and potentially fish mortalities arising from infection (Romero et al., 2022). Affected farming regions have resulted in widescale depopulation and fallowing measures, such as in Faroe Islands (2000–2005) (Christiansen et al., 2011) and Chile (2007–2009) (Mardones et al., 2009; Mardones et al., 2011). In Scotland, control measures applied to an

outbreak in 1998–1999 (Anon, 2000; Stagg, 2003) cost over £20 M in 1999 estimates (Hastings et al., 1999). A daily mortality rate of 5% in a single pen containing 15,000 market-sized salmon could result in a potential market sales loss exceeding US$10,000 per day, as previously reported by Hammell and Dohoo (2005) during outbreaks in the late 1990s.

In farmed salmon, various ISAV control and mitigation practices have been reported in the literature. These include multiple biosecurity measures such as establishing disease control zones with heightened surveillance, culling infected cages or entire farm populations, implementing year-class separation, applying strict biosecurity protocols during live fish transport, fallowing production sites between generations, and disinfecting wastewater from slaughterhouses and hatchery water supplies, in addition to vaccination and selective breeding programs (Gustafson et al., 2005; Nérette et al., 2008; Alvial et al., 2012; Bartlett, 2017).

Depopulation of ISAV positive net pens and/ or entire farm is one of the few disease containment options. However, depopulation is a costly intervention and policy decisions and timelines may be influenced by various factors, such as fish age, the clinical severity, and the risk of exposure to other active ISA-negative populations (farmed and wild) (Qviller et al., 2020; Gautam et al., 2023).The effectiveness of ISAV containment is influenced by the timing of detection and suitable, stringent biosecurity measures, such as containment of infective harvest wastewater, are practiced (Falk and Aamelfot, 2017). However, delayed application of those measures could lead to infection spread and less effective pathogen control.

Also, vaccination efficacy to combat ISAV infection remains an open question (Falk, 2014). Fish are frequently stressed and have a variety of side effects or have weakened immunity, depending on the vaccine and how it is administered, also, fish that have received vaccinations may still be infected with the virus and hence transmit the infection to other fish (Kibenge et al., 2004; Chase-Topping et al., 2021). There is also a concern that vaccinated fish may produce false positive ISAV test findings, disqualify facilities from ISA free compartment designation and prohibit the export of fish from those facilities (OIE, 2016).

ISAV vaccines and their effects are mostly presented in non-peer-reviewed conference abstracts and internet publications, resulting in a paucity of rigorous publications of the field performance of ISAV vaccines (Falk, 2014). Furthermore, disease cohabitation experiments only assess vaccine effects on mortality of susceptible fish exposed to the virus under artificial conditions, not under natural transmission factors (Chase-Topping et al., 2021).

Under experimental infection, selective breeding of Atlantic salmon has previously been reported to increase their resistance to clinical manifestations associated with ISAV, *Aeromonas salmonicida* (furunculosis), and infectious pancreatic necrosis virus (Kjøglum et al., 2008). Also, selective breeding combined with vaccination could reduce ISAV transmission (Chase-Topping et al., 2021). Nevertheless, selective breeding could have some unexpected consequences, including reduction of genetic diversity, reduced fitness, and increased vulnerability to other diseases and environmental changes (Zenger et al., 2019).

Due to the conflicting narratives surrounding ISAV control measures in the literature, a scoping review is proposed to investigate the various ISAV control practices reported in academic studies, as well as publicly available governmental measures employed by the most affected countries. By incorporating current policies and practices into our review, we aim to gain a deeper understanding of the most effective strategies for controlling and mitigating ISAV.

1.2.Objectives

The scoping review's objective is to answer the question "In farmed salmon, what are the control and mitigation practices of the infectious salmon anaemia virus?".

2. Methods

2.1.Eligibility criteria

The following types of analytical research will be included in this review: observational studies (including cohort, case control, and cross-sectional studies), as well as experimental studies (including randomized control trials). Review articles and publicly available government reports will also be considered. Case reports and case series will not be included. The search will cover the period from 1984, when ISA was first documented in Norway (Thorud & Djupvik, 1988), to the present. To allow comprehensive search, no limits will be placed on the language of full text.

2.2.Information sources

CAB Abstracts (via EBSCO host), PubMed, Scopus, and the Earth, Atmospheric & Aquatic Science Collection (via ProQuest) will be searched simultaneously for eligible studies using a Boolean search strategy developed with the assistance of a librarian (KM). The grey literature will be searched through Google scholar, furthermore, the reference list of the retrieved articles will be consulted to look for any relevant references not included in the scoping review list.

167 *2.3.Search*

168 The search strategy through the four databases is presented in Table 1.

169 **Table 1.** Scoping review search protocol

170 Preliminary search conducted in CAB abstracts (via EBSCO host). Date of search
171 19/09/2024

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#	Search	Results
1	(biosecurity OR depopulation OR cull* OR fallowing OR vaccination OR treatment OR antiviral OR quarantine OR movement restrictions OR movement control OR eradication OR mitigation)	2,429,224
2	(salmo salar OR Atlantic salmon OR farmed salmon OR farming salmon)	15,249
3	(ISAV OR ISA virus OR ISA OR infectious salmon anemia virus OR infectious salmon anemia OR Orthomyxoviridae OR orthomyxovirus)	39,730
4	1 and 2 and 3	156

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174 Preliminary search conducted in PubMed.

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#	Search	Results
1	(biosecurity OR depopulation OR cull* OR fallowing OR vaccination OR treatment OR antiviral OR quarantine OR movement restrictions OR movement control OR eradication OR mitigation)	14,535,595
2	(salmo salar OR Atlantic salmon OR farmed salmon OR farming salmon)	7,882
3	(ISAV OR ISA virus OR ISA OR infectious salmon anemia virus OR infectious salmon anemia OR Orthomyxoviridae OR orthomyxovirus)	82,071
4	1 and 2 and 3	147

176

177 Preliminary search conducted in Scopus.

#	Search	Results
1	(TITLE-ABS-KEY(biosecurity) OR TITLE-ABS-KEY(depopulation) OR TITLE-ABS-KEY(cull*)) OR TITLE-ABS-KEY(fallowing) OR TITLE-ABS-KEY(vaccination) OR TITLE-ABS-KEY(treatment) OR TITLE-ABS-KEY(antiviral) OR TITLE-ABS-KEY(quarantine) OR TITLE-ABS-KEY(movement restrictions) OR TITLE-ABS-KEY(movement control) OR TITLE-ABS-KEY(eradication) OR TITLE-ABS-KEY(mitigation))	11,439,553
2	(TITLE-ABS-KEY(salmo AND salar) OR TITLE-ABS-KEY(atlantic AND salmon) OR TITLE-ABS-KEY(farmed AND salmon) OR TITLE-ABS-KEY(farming AND salmon))	17,388
3	(TITLE-ABS-KEY(isa) OR TITLE-ABS-KEY(isav) OR TITLE-ABS-KEY(isa AND virus) OR TITLE-ABS-KEY(infectious AND salmon AND anemia AND virus) OR TITLE-ABS-KEY(infectious AND salmon AND anemia) OR TITLE-ABS-KEY(orthomyxoviridae)) OR TITLE-ABS-KEY(orthomyxovirus))	45,384
4	1 and 2 and 3	128

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179 Preliminary search conducted in Earth, Atmospheric & Aquatic Science Collection via
180 ProQuest.

#	Search	Results
1	(biosecurity OR depopulation OR cull* fallowing OR vaccination OR treatment OR antiviral OR quarantine OR movement restrictions OR movement control OR eradication OR mitigation)	996,767
2	(salmo salar OR Atlantic salmon OR farmed salmon OR farming salmon)	32,559
3	(ISAV OR ISA virus OR ISA OR infectious salmon anemia virus OR infectious salmon anemia OR Orthomyxoviridae OR orthomyxovirus)	14,017
4	1 and 2 and 3	348

2.4. Selection of sources of evidence

The search results from each database, in addition to selected articles from the grey literature search, will be imported to Covidence, a web-based software designed to streamline the systematic/scoping review process commonly used in health and social sciences research (Kellermeyer et al., 2018).

A primary screening round of the titles and abstracts will be conducted by two independent authors (AA and AR). The second round will screen full articles. At any screening level, discrepancies will be reviewed by both KLH and KT to reach a consensus decision on inclusion or exclusion.

2.5. Data charting process

Data charting process will be done in Microsoft Excel by AA and AR independently. If there is disagreement, this will first be attempted to be resolved through discussion, if a collective agreement cannot be reached, co-authors (KLH and KT) will be consulted. The data charting form will be pre-tested using a random sample of studies, and any improvements made as necessary based on feedback. Once data charting has been completed, the Excel will be locked to avoid unintentional alterations during the analysis phase.

2.6. Data items

The subsequent data elements are suggested for extraction from the literature. These may change as the study progresses to include additional or revised responses.

Regarding study characteristics; study ID, year, season, country, study design, study duration. For the population of interest; numbers of infected fish / net pens and or farms,

stage of infection (pre-smolt, smolt or adult), distance between infected net pens and or farms. Regarding the intervention (control procedures);

- Vaccine types, vaccine names (scientific or commercial), vaccine dose, and administration methods
- Biosecurity measures
- Other control / mitigation practices
- The reported key performance measures to assess the effectiveness of a control program; mortality rate, ISA incidence rate, relative percent survival, or any similar measure

2.7. Critical appraisal

Since this is a scoping review, no critical evaluation of the literature is going to be done.

2.8. Synthesis of results

To provide a concise summary of the findings, descriptive statistics will be utilized. These statistics will be given in the form of tables, figures, and descriptive text. To address the gaps in the existing literature, we will provide a summary of various ISAV control strategies that also include currently implemented practices.

2.9. Discussion

This scoping review aims to provide a comprehensive and detailed overview of the current state of knowledge, research advancements, and existing strategies related to the control ISAV. This study will systematically analyze and synthesize existing literature to offer

valuable qualitative information on the most effective methods for control and management of ISAV in farmed salmon populations.

The findings of this scoping review will serve as a significant resource for fish farmers, aquaculture sector stakeholders, researchers, and policymakers by presenting well-founded suggestions on the ideal control measures for ISA outbreaks that will help to mitigate its impact on salmon population.

Funding

Funding was received from the Atlantic Fisheries Fund (AFF).

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