University of Prince Edward Island

Faculty of Veterinary Medicine
Summary of Dissertation

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DEGREE OF DOCTOR OF PHILOSOPHY

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Modeling infectious disease risk in Canadian Atlantic salmon aquaculture with a particular focus on Infectious salmon anemia

Atlantic salmon (AS) is the most extensively farmed marine finfish in Canada. High stocking densities in net-pen systems facilitate pathogen transmission within and between sites, causing mortality, impaired growth, and economic losses. Although pathogens spread through live fish transfers, the transmission risk associated with fish transfers has not been evaluated using network analysis in Canadian AS aquaculture. The first chapter of this thesis applied network analysis to model Atlantic salmon movements on Canada's west coast. The British Columbian AS transfer network is structured around a small number of highly connected facilities, allowing surveillance efforts to focus on key hubs. Targeted removal of about 20% of the most connected facilities from pathogen transfer network through movement restrictions, vaccination, or fallowing could reduce potential outbreak size by approximately 75%. As most of these hubs were freshwater hatcheries, maintaining strong hatchery biosecurity is critical to preventing pathogen spread to marine grow-out sites. On the eastern coast of Canada, infectious salmon anemia virus (ISAV) is the most concerning viral pathogen affecting AS, and the subsequent chapters of this thesis focus on ISAV and the disease it causes. Two systematic reviews synthesized global evidence on ISAV transmission dynamics and risk factors for ISAV and ISA. A similar finding of reduced risk of ISAV or ISA was observed as the distance between susceptible and infected marine sites increased. This evidence was also supported by a Cox proportional hazards analysis of longitudinal data collected from AS farms in eastern Canada and Maine, USA, which demonstrated that proximity to an infected neighboring production cycle was a significant risk factor for earlier detection of HPR-deleted ISAV. It also reported 25 distinct HPR-deleted ISAV genotypes, with HPR4 being the most prevalent in marine-raised AS. This thesis advances the understanding of the contact structure of Canadian AS aquaculture through live fish transfer, as well as the risk of pathogen transmission, particularly ISAV transmission on the East Coast. Furthermore, this thesis highlights the importance of collective effort by industry, researchers, regulators, and personnel working in this sector, as well as transparent, timely data sharing, for sustainable salmon aquaculture.

Publications

Raquib A, Hammell KL, Sanchez J, O'Brien N, Thakur KK. Network analysis of farmed Atlantic salmon movements in British Columbia, Canada. Frontiers in Veterinary Science. 2025 June; 12:1568484. https://doi.org/10.3389/fvets.2025.1568484

Thapa PC, Raquib A, Mears K, Sanchez J, Saksida S, Hammell KL, Thakur KK. Global genetic diversity of infectious salmon anemia virus (ISAV) a scoping review protocol. PloS one. 2025 Jun 17;20(6):e0325115. https://doi.org/10.1371/journal.pone.0325115

Abdallah A, Raquib A, McCaffrey K, Hammell KL, Thakur KK. Control and mitigation of infectious salmon anemia virus in farmed salmon: protocol for scoping review. Systematic Reviews for Animals & Food. 2025.

Submitted:

Raquib A, Thapa PC, Sanchez J, O'Brien N, Hammell KL, Thakur KK. Transmission dynamics of infectious salmon anemia: a systematic review. (Under Review in Reviews in Aquaculture).

Raquib A, Thapa PC, Sanchez J, O'Brien N, Hammell KL, Thakur KK. Risk factors for infectious salmon anemia virus infection and clinical infectious salmon anemia in Atlantic salmon: a systematic review. (Under Review in Reviews in Fisheries Science and Aquaculture).

In preparation:

Raquib A, Hammell KL, Sanchez J, O'Brien N, Groman D, Hawkins L, Carlos J, Saksida S, Thakur KK. Descriptive epidemiology of infectious salmon anemia virus (ISAV) variants, and multiple-membership cox proportional hazard analysis of time to first detection of ISAV in Atlantic salmon marine sites. In preparation for submission to Aquaculture.

Abdallah A, Raquib A, McCaffrey K, Hammell KL, Thakur KK. A scoping review on control and mitigation of infectious salmon anemia virus in farmed salmon. In preparation for submission to Reviews in Aquaculture.

Thapa PC, Raquib A, Mears K, Sanchez J, Saksida S, Hammell KL, Thakur KK. Global genetic diversity of infectious salmon anemia virus (ISAV): a scoping review. In preparation for submission to Reviews in Aquaculture.

Presentations

Raquib A, Hammell KL, Brown A, Hawkins L, Saksida S, Thakur KK. Space-time clustering and risk factors for the time to first detection of infectious salmon anemia in Atlantic Canada and Maine, USA. Canadian Emerging Veterinary Scholars Summit (CEVSS). Calgary, Canada, 2025. Oral presentation.

Raquib A, Thapa PC, Hammell KL, Thakur KK. Transmission dynamics of infectious salmon anemia: a systematic review. Aquaculture Association of Canada (AAC) conference. Fredericton, New Brunswick, Canada, 2025. Oral presentation.

Raquib A, Hammell KL, Brown A, Hawkins L, Saksida S, Thakur KK. Space-time clustering and risk factors for the time to first detection of infectious salmon anemia in Atlantic Canada and Maine, USA. Aquaculture Association of Canada (AAC) conference. Fredericton, New Brunswick, Canada, 2025. Oral presentation.

Raquib A, Thapa PC, Hammell KL, Thakur KK. Risk factors for infectious salmon anemia virus infection and clinical infectious salmon anemia in Atlantic salmon and rainbow trout: a systematic review. Aquaculture Association of Canada (AAC) conference. Fredericton, New Brunswick, Canada, 2025. Poster presentation.

Raquib A. Tracing the Spread of a Deadly Viral Infection in Salmon Farms. 3 Minute Thesis competition, UPEI, Canada, 2025. Oral presentation.

Raquib A, Ahsan MI, Talukder H, Uddin MM, Debnath K, Hussain MS, Paul S, Ahmed SSU. Seroprevalence of Brucellosis in Humans and Animals in South Asian Countries: A systematic review and meta-analysis. One Health: AMR & Emerging Zoonoses conference. Calgary, Canada, 2025. Poster presentation.

Raquib A, Hammell KL, Sanchez J, O'Brien N, Thakur KK. Network analysis of Atlantic salmon movements in British Columbia, Canada. November 2024. International Symposium on Veterinary Epidemiology and Economics (ISVEE 17). Sydney, Australia,2024. 5-minute Oral presentation + Poster presentation.

Thakur KK, Raquib A, Hammell KL. Detection of bacterial diseases before transfer of fish from Atlantic salmon hatcheries in British Columbia, Canada. Aqua Epi III. Lucknow, India, 2023. Poster presentation.

Biographical Data

My name is Ahsan Raquib. I am originally from Bangladesh, where I completed both my Doctor of Veterinary Medicine (DVM) and Master's degrees. My master's research focused on a systematic review and meta-analysis of the seroprevalence of brucellosis in humans and animals across South Asian countries. I am currently a PhD candidate in Aquatic Epidemiology in the Department of Health Management at the Atlantic Veterinary College, University of Prince Edward Island. My doctoral research examines infectious disease risk in Canadian Atlantic salmon aquaculture, with a particular focus on infectious salmon anemia (ISA), a viral disease caused by infectious salmon anemia virus (ISAV) that affects Atlantic salmon farms on the eastern coast of Canada.

Born in Sylhet, Bangladesh.

Awards Received

2025- Atlantic Canada Center for Disease Ecology Modelling (ACCDMi) scholarship

2025- Nominated to represent the Atlantic Veterinary College at the Canadian Emerging Veterinary Scholars Summit (CEVSS), Calgary, Canada

2025- Dr. Ian Dohoo Award, Atlantic Veterinary College, University of Prince Edward Island

2025- One Health: AMR & Emerging Zoonoses Travel Award

2025- Student Research travel funding, University of Prince Edward Island

2024- G. Murray and Hazel Hagerman Scholarship, Atlantic Veterinary College, University of Prince Edward Island

2024- Graduate student research conference travel award, University of Prince Edward Island

2024-James E. Bateman Memorial Scholarship, Atlantic Veterinary College, University of Prince Edward Island

2020- Sylhet Agricultural University Research System (SAURES) scholarship