

Hallazgos histopatológicos en órganos de salmón del atlántico infectados con dos cepas de *Piscirickettsia salmonis*.

L. Asencio^{1*}, F. Vera¹ y A. Romero²

¹ Facultad de Ciencias de la Naturaleza, Universidad San Sebastián sede de la Patagonia, Puerto Montt, Chile

² Laboratorio de inmunología y estrés de Organismos Acuáticos, Facultad de Ciencias Veterinarias, Universidad Austral de Chile, Valdivia, Chile

*leslieasencioeve@gmail.com

- Agius, C. 1980. Phylogenetic development of melano-macrophage centres in fish. *Journal of Zoology*, 191: 11-31.
- Albornoz, R., Valenzuela, K., Pontigo, J. P., Sánchez, P., Ruiz, P., Avendaño-Herrera, R., Romero, A., Oliver, C., & Yáñez, A. 2017. Identification of chemotaxis operon cheYZA and cheA gene expression under stressful conditions in *Piscirickettsia salmonis*. *Microbial Pathogenesis*, 107: 436-441
- Almendras, F. & Fuentealba, I. 1997. Salmonid rickettsial septicemia caused by *Piscirickettsia salmonis*: a review. *Diseases of Aquatic Organisms*, 29: 137-144.
- Almendras, F., Fuentealba, I., Frederick Markham, R. & Speare, D. 2000. Pathogenesis of liver lesions caused by experimental infection with *Piscirickettsia salmonis* in juvenile Atlantic salmon, *Salmo salar* L. *Journal of Veterinary Diagnostic Investigation: Official Publication of the American Association of Veterinary Laboratory Diagnosticians, Inc*, 12: 552-557.
- Almendras, F., Jones, S., Fuentealba, C. & Wright, G. 1997. In vitro infection of a cell line from *Ictalurus nebulosus* with *Piscirickettsia salmonis*. *Revue Canadienne de Recherche Veterinaire [Canadian Journal of Veterinary Research]*, 61: 66-68.
- Bucke, D. 1972. Myxosporidiosis in coho salmon. *The Veterinary Record*, 90: 483.
- Belsare, A. & Mushrif, M. 2012. Histopathological image analysis using image processing techniques: An overview. *Signal y Image Processing: An International Journal*, 3: 4.
- Bravo, S. & Campos, M. 1989. Coho salmon syndrome in Chile. *Fish Health Section Newsletter, American Fisheries Society*, 17: 3.
- Branson, E., & Nieto Diaz-Muñoz, D. 1991. Description of a new disease condition occurring in farmed coho salmon, *Oncorhynchus kisutch* (Walbaum), in South America. *Journal of Fish Diseases*, 14: 147-156.
- Birkbeck, T., Rennie, S., Hunter, D., Laidler, L. & Wadsworth, S. 2004. Infectivity of a Scottish isolate of *Piscirickettsia salmonis* for Atlantic salmon *Salmo salar* and immune response of salmon to this agent. *Diseases of Aquatic Organisms*, 60: 97-103.
- Bohle, H., Henríquez, P., Grothusen, H., Navas, E., Sandoval, A., Bustamante, F., Bustos, P. & Mancilla, M. 2014. Comparative genome analysis of two isolates of the fish pathogen *Piscirickettsia salmonis* from different hosts reveals major differences in virulence-associated secretion systems. *Genome Announcements*, 2: 6.
- Cubillos, V., Alvarado, J. & Schäfer, M. 1990. Características anatomopatológicas del síndrome del salmón coho (S.S.C.), nueva enfermedad de los salmonídeos. *Patología Animal*, 4: 14-17.
- Cubillos, V., López, I. & Alberdi, A. 2001. Aspectos lesionales microscópicos en hígados de salmonídeos, provenientes de Centros de Cultivo de la X^a a XII^a región de Chile (1988-1998). *Archivos de Medicina Veterinaria*, 33: 203-216.
- Cvitanich, J., Garate, O. & Smith, C. 1990. Etiological agent in a Chilean coho disease isolated and confirmed by Koch's postulates. *American Fisheries Society Newsletter*, 18: 1-2.
- Fletcher, C. 2020. *Diagnostic Histopathology of Tumors, 2 Volume Set: Expert consult - online and print (5th ed.)*. Elsevier, Países Bajos.
- Fryer, J. & Hedrick, R. 2003. *Piscirickettsia salmonis*: a Gram-negative intracellular bacterial pathogen of fish. *Journal of Fish Diseases*, 26: 251-262.
- Fryer, J., Lannan, C., Giovannoni, S. & Wood, N. 1992. *Piscirickettsia salmonis* gen. nov., sp. nov., the causative agent of an epizootic disease in salmonid fishes. *International Journal of Systematic Bacteriology*, 42: 120-126.
- House, M., Bartholomew, J., Winton, J. & Fryer, J. 1999. Relative virulence of three isolates of *Piscirickettsia salmonis* for coho salmon *Oncorhynchus kisutch*. *Diseases of Aquatic Organisms*, 35: 107-113.
- Hernández, R., Fernandez, C. & Baptista P. 2014. *Metodología de la investigación (6a ed.)*. Mc Graw Hill, México D.F.
- Huancaré, R. 2014. Identificación histopatológica de lesiones inducidas por bioacumulación de metales pesados en branquias, hígado y músculo de trucha arcoíris (*Oncorhynchus mykiss*) de cultivo en etapa comercial de la laguna de Mamacocha, área de influencia minera. Tesis de pregrado, Universidad Nacional Mayor de San Marcos, Lima.
- Larenas H., Hidalgo, L., Garcés A., Fryer, J. & Smith S. 2010. *Piscirickettsiosis*: lesiones en salmón del atlántico (*Salmo salar*) infectados naturalmente con *Piscirickettsia salmonis*. *Avances En Ciencias Veterinarias*, 10 (1).
- Larenas, J., Bartholomew, J., Troncoso, O., Fernández, S., Ledezma, H., Sandoval, N., Vera, P., Contreras, J. & Smith, P. 2003. Experimental vertical transmission of *Piscirickettsia salmonis* and in vitro study of attachment and mode of entrance into the fish ovum. *Diseases of Aquatic Organisms*, 56: 25-30.
- Larenas, J., Contreras, J., Oyanedel, S., Morales, M. & Smith, P. 1997. Efecto de la densidad poblacional y temperatura en truchas arco iris (*Oncorhynchus mykiss*) inoculadas con *Piscirickettsia salmonis*. *Archivos de Medicina Veterinaria*, 29: 113-119.

Levipan, H., Irgang, R., Yáñez, A. & Avendaño-Herrera, R. 2020. Improved understanding of biofilm development by *Piscirickettsia salmonis* reveals potential risks for the persistence and dissemination of piscirickettsiosis. *Scientific Reports*, 10: 12224.

Michel, C. & Garcia, C. 2003. Virulence stability in *Flavobacterium psychrophilum* after storage and preservation according to different procedures. *Veterinary Research*, 34: 127-132.

Maisey, K., Montero, R. & Christodoulides, M. 2017. Vaccines for piscirickettsiosis (salmonid rickettsial septicaemia, SRS): the Chile perspective. *Expert Review of Vaccines*, 16: 215-228.

Meza, K., Inami, M., Dalum, A., Lund, H., Bjelland, A., Sørum, H., & Løvoll, M. 2019. Comparative evaluation of experimental challenge by intra-peritoneal injection and cohabitation of Atlantic salmon (*Salmo salar* L) after vaccination against *Piscirickettsia salmonis* (EM90-like). *Journal of Fish Diseases*, 42: 1713-1730.

Mauel, M. & Miller, D. 2002. Piscirickettsiosis and piscirickettsiosis-like infections in fish: a review. *Veterinary Microbiology*, 87: 279-289.

McCloughlin, M., Graham, D., Norris, A., Matthews, D., Foyle, L., Rowley, H. & Todd, D. 2006. Virological, serological and histopathological evaluation of fish strain susceptibility to experimental infection with salmonid alphavirus. *Diseases of Aquatic Organisms*, 72: 125-133.

Montalico, E., Rodríguez, H., Larenas, J. & Ardito, F. 2021. Detección y asociación de *Piscirickettsia salmonis* en órganos y heces de salmón coho (*Oncorhynchus kisutch*) cultivado en el mar. *Revista de Investigaciones Veterinarias Del Peru*, 32: e18041.

Olsen, A., Melby, H., Speilberg, L., Evensen, Ø. & Håstein, T. 1997. *Piscirickettsia salmonis* infection in Atlantic salmon *Salmo salar* in Norway - epidemiological, pathological and microbiological findings. *Diseases of aquatic organisms*, 31: 35-48.

Passantino, L., Cianciotta, A., Jirillo, F., Carrassi, M., Jirillo, E., & Passantino, G. 2005. Lymphoreticular system in fish: Erythrocyte-mediated immunomodulation of macrophages contributes to the formation of melanomacrophage centers. *Immunopharmacology and Immunotoxicology*, 27: 147-161.

Pontigo, J., Espinoza, C., Hernandez, M., Nourdin, G., Oliver, C., Avendaño-Herrera, R., Figueroa, J., Rauch, C., Troncoso, J., Vargas-Chacoff, L. & Yáñez, A. 2021. Protein-Based Vaccine Protect Against *Piscirickettsia salmonis* in Atlantic Salmon (*Salmo salar*). *Frontiers in Immunology*, 12, 602689. <https://doi.org/10.3389/fimmu.2021.602689>

Quintanilla, J. C., González, M. P., García, J. P., Olmos, P., y Contreras-Lynch, S. (2021). Horizontal transmission of *Piscirickettsia salmonis* from the wild sub-Antarctic notothenioid fish *Eleginops maclovinus* to rainbow trout (*Oncorhynchus mykiss*) under experimental conditions. *Journal of Fish Diseases*, 44: 993-1004.

Rodger, H. & Drinan, E. 1993. Observation of a rickettsia-like organism in Atlantic salmon, *Salmo salar* L.; in Ireland. *Journal of Fish Diseases*, 16: 361-370.

Rees, E., Ibarra, R., Medina, M., Sanchez, J., Jakob, E., Vanderstichel, R. & St-Hilaire, S. 2014. Transmission of *Piscirickettsia salmonis* among salt water salmonid farms in Chile. *Aquaculture (Amsterdam, Netherlands)*, 428-429: 189-194.

Rozas-Serri, M. 2022. Why does *Piscirickettsia salmonis* break the immunological paradigm in farmed salmon? Biological context to understand the relative control of piscirickettsiosis. *Frontiers in Immunology*, 13: 856896.

Rozas-Serri, M. & Enríquez, R. 2014. Piscirickettsiosis and *Piscirickettsia salmonis* in fish: a review. *Journal of Fish Diseases*, 37: 163-188.

Rozas-Serri, M., Ildefonso, R., Peña, A., Enríquez, R., Barrientos, S. & Maldonado, L. 2017. Comparative pathogenesis of piscirickettsiosis in Atlantic salmon (*Salmo salar* L.) post-smolt experimentally challenged with LF-89-like and EM-90-like *Piscirickettsia salmonis* isolates. *Journal of Fish Diseases*, 40: 1451-1472.

Rozas-Serri, M. 2022. Why does *Piscirickettsia salmonis* break the immunological paradigm in farmed salmon? Biological context to understand the relative control of piscirickettsiosis. *Frontiers in Immunology*, 13: 856896.

Saavedra J., Hernandez, N., Osses, A., Castillo, A., Cancino, A., Grothusen, H., Navas, E., Henríquez, P., Bohle, H., Bustamante, F., Bustos, P. & Mancilla M. 2017. Prevalence, geographic distribution and phenotypic differences of *Piscirickettsia salmonis* EM-90-like isolates. *J. Fish Dis.*, 40: 1055-1063.

Sernapesca. 2021. Informe sanitario de agua dulce y mar año 2021 (Enero – Noviembre) [http://www.sernapesca.cl/sites/default/files/informe_sanitario_con_informacion_sanitaria_de_agua_dulce_y_mar_ano_2021_20220425.pdf]

Santibáñez, N., Vega, M., Pérez, T., Yáñez, A., González-Stegmaier, R., Figueroa, J., Enríquez, R., Oliver, C. & Romero, A. 2020. Biofilm produced in vitro by *Piscirickettsia salmonis* generates differential cyto-toxicity levels and expression patterns of immune genes in the Atlantic salmon cell line SHK-1. *Microorganisms*, 8: 1609.

Santos Vidal, S. 2017. Tinción Hematoxilina-Eosina. [<http://62.204.194.43/fez/view/bibliuned:master-Ciencias-CyTQ-Ssantos>]

Smith, P. 2015. Patogenia de piscirickettsiosis: estudio sobre la infectividad de *Piscirickettsia salmonis* y el efecto de sus productos extracelulares. Tesis de doctorado, Córdoba.

Smith, P., Contreras, J., Rojas, M., Guajardo, A., Díaz, S. & Carbonero, A. 2015. Infectivity of *Piscirickettsia salmonis* in immersion-bath exposed rainbow trout *Oncorhynchus mykiss* (Walbaum) fry. *Journal of Fish Diseases*, 38: 765-770.

Soto, E., Halliday-Simmonds, I., Francis, S., Kearney, M. T., y Hansen, J. D. (2015). Biofilm formation of *Francisella noatunensis* subsp. orientalis. *Veterinary Microbiology*, 181 (3-4), 313-317. <https://doi.org/10.1016/j.vetmic.2015.10.007>

Thi, E., Lambert, U. & Reiner, N. 2012. Sleeping with the enemy: how intracellular pathogens cope with a macrophage lifestyle. *PLoS Pathogens*, 8: e1002551.

Vera, F. 2022. Rol de la producción de biofilm de *Piscirickettsia salmonis* sobre su virulencia y patogenicidad en la infección de salmón del Atlántico (*Salmo salar*). Tesis de doctorado. Valdivia.

Zhang, J.-M. & An, J. 2007. Cytokines, inflammation, and pain. *International Anesthesiology Clinics*, 45: 27-37.