

Efecto de la temperatura del medio de fecundación *in vitro* sobre la cinética de la motilidad de espermatozoides recolectados por diferentes métodos (*Salmo salar*)

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- Alavi, S. M. & Cosson, J. 2005. Sperm motility in fishes. I. Effects of temperature and pH: a review. *Cell Biology International*, 29: 101-110.
- Beirão, J., Boulais, M., Gallego, V., O'Brien, J., Peixoto, S., Robeck, T. & Cabrita, E. 2019. Sperm handling in aquatic animals for artificial reproduction. *Theriogenology*, 133: 161-178.
- Bozkurt, Y. & Secer, S. 2006. Relationship between spermatozoa motility, egg size, fecundity, and fertilization success in brown trout (*Salmo trutta fario*). *Pakistan Journal of Biological Sciences*, 9: 2141-2144.
- Boryshpolets, S., Kholodnyy, V., Cosson, J. & Dzyuba, B. 2018. Fish sperm motility analysis: the central role of the flagellum. *Reproduction, Fertility and Development*, 30: 833-841.
- Cosson, J., Groison, A. L., Suquet, M., Fauvel, C., Dreanno, C. & Billard, R. 2008. Studying sperm motility in marine fish: an overview on the state of the art. *Journal of Applied Ichthyology*, 24: 460-486.
- Cosson, J. 2010. Frenetic activation of fish spermatozoa flagella entails short-term motility, portending their precocious decadence. *Journal of Fish Biology*, 76: 240-279.
- Díaz, R., Lee-Estevéz, M., Quiñones, J., Dumorné, K., Short, S., Ulloa-Rodríguez, P., et al. 2019. Changes in Atlantic salmon (*Salmo salar*) sperm morphology and membrane lipid composition related to cold storage and cryopreservation. *Animal Reproduction Science*, 204: 50-59.
- Fenkes, M., Fitzpatrick, J., Ozolina, K., Shiels, H. & Nudds, R. 2017. Sperm in hot water: direct and indirect thermal challenges interact to impact on brown trout sperm quality. *Journal of Experimental Biology*, 220: 2513-2520.
- Figueroa, E., Valdebenito, I., Merino, O., Ubilla, A., Risopatrón, J. & Farías, J. 2016. Cryopreservation of Atlantic salmon (*Salmo salar*) sperm: effects on sperm physiology. *Journal of Fish Biology*, 89: 1537-1550.
- Gallego, A., Pérez, L., Asturiano, J. & Yoshida, M. 2013. Relationship between spermatozoa motility parameters, sperm/egg ratio, and fertilization and hatching rates in pufferfish (*Takifugu niphobles*). *Aquaculture*, 416: 238-243.
- Gallego, V., Pérez, L., Asturiano, J. & Yoshida, M. 2014. Sperm motility parameters and spermatozoa morphometric characterization in marine species: a study of swimmer and sessile species. *Theriogenology*, 82: 668-676.
- Gallego, V. & Asturiano, J. 2018. Sperm motility in fish: technical applications and perspectives through CASA-Mot systems. *Reprod. Fertil. Dev.*, 30: 820-832.
- González-López, W., Ramos-Júdez, S., Giménez, I. & Duncan, N. 2019. Sperm contamination by urine in Senegalese sole (*Solea senegalensis*) and the use of extender solutions for short-term chilled storage. *Aquaculture*, 516: 734649.
- Hagedorn, M., McCarthy, M., Carter, V. & Meyers, S. A. 2012. Oxidative stress in zebrafish (*Danio rerio*) sperm. *PLOS One*, 7: 2-12.
- He, X., Yan, Y., Delaurier, A. & Postlethwait, J. 2011. Observation of miRNA gene expression in zebrafish embryos by in situ hybridization to microRNA primary transcripts. *Zebrafish*, 8: 1-8.
- Jing, R., Huang, C., Bai, C., Tanguay, R. & Dong, Q. 2009. Optimization of activation, collection, dilution, and storage methods for zebrafish sperm. *Aquaculture*, 290: 165-171.
- Judycka, S., Nynca, J., Hliwa, P. & Ciereszko, A. 2021. Characteristics and cryopreservation of semen of sex-reversed females of salmonid fish. *International Journal of Molecular Sciences*, 22: 964.
- Kholodnyy, V., Gadêlha, H., Cosson, J. & Boryshpolets, S. 2020. How do freshwater fish sperm find the egg? The physicochemical factors guiding the gamete encounters of externally fertilizing freshwater fish. *Reviews in Aquaculture*, 12: 1165-1192.
- Koppers, A., De Iulius, G., Finnie, J., McLaughlin, E. & Aitken, R. 2008. Significance of mitochondrial reactive oxygen species in the generation of oxidative stress in spermatozoa. *Journal of Clinical Endocrinology & Metabolism*, 93: 3199-3207.
- Linhart, O., Walford, J., Sivaloganathan, B. & Lam, T. 1999. Effects of osmolality and ions on the motility of stripped and testicular sperm of freshwater- and seawater-acclimated tilapia, *Oreochromis mossambicus*. *Journal of Fish Biology*, 55: 1344-1358.
- Liu, Q., Li, J., Xiao, Z., Ding, F., Yu, D. & Xu, X. 2007. Use of computer-assisted sperm analysis (CASA) to evaluate the quality of cryopreserved sperm in red seabream (*Pagrus major*). *Aquaculture*, 263: 20-25.
- Liu, Y., Yang, H., Torres, L. & Tiersch, T. 2018. Activation of free sperm and dissociation of sperm bundles (spermatozeugmata) of an endangered viviparous fish, *Xenotoca eiseni*. *Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology*, 218: 35-45.
- Mansour, N., Lahnsteiner, F. & Patzner, R. 2004. Seminal vesicle secretion of African catfish, its composition, its behaviour in water and saline solutions and its influence on gamete fertilizability. *Journal of Experimental Zoology Part A: Comparative Experimental Biology*, 301: 745-755.

Merino, O., Aguagüiña, W., Esponda, P., Risopatrón, J., Isachenko, E., Isachenko, V. & Sánchez, R. 2015. Protective effect of butylated hydroxytoluene on sperm function in human spermatozoa cryopreserved by vitrification technique. *Andrologia*, 47: 186-193.

Merino, O., Dumorné, K., Leidy, S., Figueroa, E., Valdebenito, I., Farías, J. & Risopatrón, J. 2020. Short-term storage sperm of coho salmon (*Oncorhynchus kisutch*) at 4°C: Effect of sperm: extender dilution ratios and antioxidant butyl-hydroxytoluene (BHT) on sperm function. *Cryobiology*, 95: 44-50.

Merino, O., Figueroa, E., Cheuquemán, C., Valdebenito, I., Isachenko, V., Isachenko, E., Sánchez, R., Farías, J. & Risopatrón, J. 2017. Short-term storage of salmonids semen in a sodium alginate-based extender. *Andrologia*, 49.

Merino, O., Figueroa, E., Valdebenito, I., Risopatrón, J., Merino, M. & Farías, J. 2024. Change in the swimming pattern of *Salmo salar* spermatozoa caused by the high temperature of the sperm motility activation medium. *Theriogenology*, 219: 49-58.

Rurangwa, E., Kime, D., Ollevier, F. & Nash, J. 2004. The measurement of sperm motility and factors affecting sperm quality in cultured fish. *Aquaculture*, 234: 1-28.

Tuset, V., Trippel, E. & de Monserrat, J. 2008. Sperm morphology and its influence on swimming speed in Atlantic cod. *Journal of Applied Ichthyology*, 24: 398-405.

Viveiros, A., Nascimento, A., Orfão, L. & Isaú, Z. 2010. Motility and fertility of the subtropical freshwater fish streaked prochilod (*Prochilodus lineatus*) sperm cryopreserved in powdered coconut water. *Theriogenology*, 74: 551-556.

Vladić, T. & Järvi, T. 2001. Sperm quality in the alternative reproductive tactics of Atlantic salmon: the importance of the loaded raffle mechanism. *Proceedings of the Royal Society B: Biological Sciences*, 268: 2375-2381.

Yanagimachi, R., Cherr, G., Pillai, M. & Baldwin, J. 1992. Factors controlling sperm entry into the micropyles of salmonid and herring eggs. *Development, Growth & Differentiation*, 34: 447-461.

Yanagimachi, R., Harumi, T., Matsubara, H., Yan, W., Yuan, S., Hirohashi, N., et al. 2017. Chemical and physical guidance of fish spermatozoa into the egg through the micropyle. *Biology of Reproduction*, 96: 780-799.