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Artificial sperm selection and cryptic male choice: What have fish and human taught us?

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Sperm competition is a process ensuing when a female mates with several males during a single reproductive cycle. Sperm quality evolution is still poorly understood because of the assumptions about the competing male behavior, which were more often investigated than the assumptions regarding behavior and physiology of the haploid spermatozoa. In the praxis of human artificial fertilization, high-quality spermatozoa are selected by swim-up technique to harvest gametes with the greatest chance of fertilizing an ovum. The markers of such sperm populations are not fully recognized. In this presentation, two aspects of sperm quality and one aspect of female fecundity were investigated. First, we investigated whether sperm numbers or ejaculate physiological quality determine the success in sperm competition in the Atlantic salmon, an externally fertilizing species that experiences high intensities of sperm competition between anadromous and precocious (parr) males on spawning grounds. Also, we predicted that large trout eggs should be preferentially fertilized due to the effects of larger target size and greater survival probability for alevines that are born from large eggs. Second, we hypothesised that gamete quality ought be reflected in the gamete size. Thus, long spermatozoa should be generally superior to shorter ones; therefore highly mobile human swim-up selected spermatozoa should be longer, and have longer mid-piece and tails which contain the molecular motor, tha axoneme, than these cell structures in the untreated sperm population. Precociously mature Atlantic salmon males (parr) produce sperm of superior quality, since parr males win in sperm competition with the anadromous males (ANOVA: $F_{1,20}=59.96$, $p<0.001$). In salmon, sperm length parameters correlated positively with ATP (multiple regression: $r^2=0.41$, $p<0.05$), energy charge (multiple regression: $r^2=0.51$, $p<0.05$) and fertilization success (ANCOVA: $F_{1,11}=6.148$, $p<0.05$). In competition between anadromous male vs precocial parr sperm with equalized spem numbers, younger precocial parr individuals achieved 3.6 times greater fertilization success than anadromous competitors. This result could partly be accounted for by greater ATP concentrations in parr ejaculates. In contrast to precociously mature parr males who fertilized all eggs irrespective of size, anadromous trout males preferentially fertilized small eggs (ANCOVA: $F_{2,11}= 6.148$, $p<0.05$). This suggests a phenotypically plastic cryptic male choice in fish originating from hatchery. Surprisingly, swim-up selected spermatozoa with short end-pice and long mitochondria (7.8 µm, CI 7.11-8.44 µm vs. 8.5 µm, CI 7.81-9.14 µm and 5.8 µm, CI 5.52-6.16 µm vs. 5.3 µm, CI 4.97-5.61 µm, both $P<0.05$, respectively). Men producing great sperm concentrations had swim-up spermatozoa with longer mid-pieces as compared to men producing low sperm concentrations in ejaculates (residuals of sexual abstinence time, model: $F_{3,13}=4.63$, $p=0.020$) but comparable sperm total length and tail endpiece length. To conclude, precociously mature salmonid parr males were found to produce ejaculates of superior physiological quality as a compensation to behavioral sub-ordinance in sperm competition. Hatchery rearing can relax selection for increased egg size due to the lack of natural predation. In humans, morphometry of spermatozoa could contribute to the clinical efficiency of swim-up selection procedure for assisted reproduction purposes: relative sperm dimensions and particulary sperm midpiece length, rather than total cell length predict the cells most likely to fertilize an ovum.

Biography

Tomislav Vladic has completed his PhD from Stockholm University and postdoctoral studies from Karolinska Institute. He is a co-editor of the book "Evolutionary Biology of the Atlantic Salmon", scheduled to appear in December 2014 at Science Publishers, CRC Press, Taylor and Francis, Boca Raton, FL, USA. He has published more than 30 scientific papers in reputed journals and proceedings of international and national conferences. He serves as an editorial board member of Medical Science Monitor, a reviewer of several scientific journals and as a Grant Reviewer for research grants for the Czech Academy of Sciences.

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