Pharmaceutical pollution alters migration in Atlantic salmon

Umeå, Sweden—Researchers at The Swedish University of Agricultural Sciences (SLU) have conducted the largest study to date investigating how pharmaceutical pollution can affect the behaviour and migration of Atlantic salmon. They found that commonly detected environmental levels of the pharmaceutical pollutant clobazam affected the river-to-sea migration success of juvenile salmon in the wild. Moreover, clobazam decreased the time taken to pass through two hydropower dams along their migration route. The study highlights how pharmaceuticals that are commonly detected in the environment can affect the behaviour and survival of wildlife.

“Pharmaceutical pollution is a rapidly increasing threat to wildlife and ecosystems globally,” said Dr Jack Brand, a researcher at SLU and first author of the new publication in the journal *Science*. Many pharmaceuticals enter aquatic ecosystems during drug manufacture, use, and disposal, resulting in more than 900 different substances having now been detected in waterways across the globe. “Psychoactive pollutants such as antidepressants and pain medications are of particular concern due to their ability to influence brain function and alter the behaviour of wildlife species,” said Assistant Professor Michael Bertram, also from SLU and the senior author of the study.

“Almost all of the existing research into the effects of pharmaceutical pollution on wildlife species has investigated the potential effects of these drugs under simplified conditions in the laboratory that do not capture real-world complexity,” said Asst. Prof. Bertram. “However, we know that animal behaviour is very sensitive to environmental conditions, meaning that behavioural effects of drug exposure seen in the laboratory may not be reflective of behavioural responses in the wild,” he said.

Using newly developed slow-release pharmaceutical implants and animal-tracking transmitters, the research team conducted a large field-based study to investigate how exposure to the common pharmaceutical pollutant clobazam (a drug that is often prescribed for sleep disorders) and the opioid pain-killer tramadol affected the behaviour and migration of juvenile Atlantic salmon (*Salmo salar*) in the River Dal, Sweden, during their migration to the Baltic Sea.

“We found that clobazam altered river-to-sea migration success, with more clobazam-exposed fish ultimately reaching the Baltic Sea relative to unexposed fish. Moreover, clobazam decreased the time taken to pass through two hydropower dams along their migration route,” said Dr Brand. “Our follow-up laboratory experiment also found that clobazam altered shoaling behaviour, suggesting that the effects observed in the wild may be due to drug-induced changes to fish social and risk-taking behaviour,” he said.

“We emphasise that any changes to migration dynamics are expected to have long-term consequences for the viability of contaminated populations. The extent of these impacts is difficult to predict, especially when considering realistic exposure scenarios in which entire ecosystems, comprising multiple trophic levels, are exposed,” said Dr Brand. “Our results demonstrate the capacity for pharmaceutical pollution to influence key behaviours of animals in the wild, with potentially wide-ranging consequences,” he said.

“Successfully migrating between spawning and feeding grounds is vital for the survival and persistence of many populations. In fact, migrating to the sea is a key life-history event for juvenile salmon, who feed and grow out in the open waters before returning to rivers to spawn,” said Asst. Prof. Bertram. “Our results show that exposure to common pharmaceutical pollutants can alter this process, with potential consequences for the persistence of populations,” he said.

Atlantic salmon are an ecologically, economically, and culturally important species that has recently been classified as endangered by the International Union for Conservation of Nature (IUCN) in parts of Europe. While overexploitation (e.g. from fishing) and habitat loss and fragmentation are the primary drivers of this worrying trend, the results of this experiment suggest that pharmaceutical pollution may also alter behaviours important for key life-history events in migratory fish. What the long-term consequences are of these effects is not clear and will require further research.

"Ours is one of the first studies to show that experimental exposure to pharmaceutical pollution can influence the behaviour and migration success of fish in the wild. The molecular targets of these drugs are often conserved across a wide variety of species, meaning that pharmaceutical pollution is likely having widespread effects," said Dr Brand. Recent analysis of pharmaceutical pollution in the world's rivers (https://www.pnas.org/doi/10.1073/pnas.2113947119) found that pharmaceuticals were detected on every continent, including Antarctica. Therefore, it is possible that pharmaceutical pollution may similarly be disrupting the behaviour and movement of fish populations around the globe. But more field-based studies under naturalistic conditions are needed.

"Pharmaceuticals play a key role in modern human and animal health and will remain important for disease management and prevention into the future. However, most pharmaceuticals exhibit poor biodegradability, and wastewater treatment processes often fail to completely remove these substances," said Professor Tomas Brodin at SLU and a co-author on the study. "Several advanced wastewater treatment methods have been successful in reducing pharmaceutical contamination. However, these remain unavailable in many parts of the world due to insufficient infrastructure and the associated costs. There are several potential solutions to address the issue of pharmaceutical pollution, including changes to regulatory measures and upgrading wastewater treatment technologies," he said.

"Members of our team have also recently highlighted the potential for green chemistry approaches—designing drugs that biodegrade more quickly in the environment or become less toxic after use—to further mitigate pharmaceutical pollution into the future (https://www.nature.com/articles/s41893-024-01374-y)," said Asst. Prof. Bertram. "While addressing pharmaceutical pollution is not simple, it is clear that a multi-pronged approach will be required to mitigate the threat of pharmaceutical contaminants to wildlife health into the future," he said.

Available for Interviews:

- Dr Jack Brand, Swedish University of Agricultural Sciences, Sweden, +44(0)7756717208, Email: jack.brand@slu.se
- Assistant Professor Michael Bertram, Swedish University of Agricultural Sciences, Sweden, +46(0)704469055, Email: michael.bertram@slu.se
- Professor Tomas Brodin, Swedish University of Agricultural Sciences, Sweden, +46(0)907868161, Email: tomas.brodin@slu.se