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ASSESSING DEVELOPMENTAL TOXICITY OF PSYCHOACTIVE POLLUTANTS USING XENOPUS LAEVIS AS A MODEL

S. Di Marino, C. Fogliano, C.M. Motta, B. Avallone, R. Carotenuto

Dept. of Biology, University of Naples Federico II, Italy

The continuous release of psychoactive compounds into aquatic systems is a growing environmental concern, largely driven by their high consumption and incomplete removal during conventional wastewater treatment processes. Consequently, they are classified as emerging contaminants. Among the most frequently reported are clonazepam, a benzodiazepine used for neurological and psychiatric disorders, and stimulants such as caffeine and nicotine, typically detected in wastewater and surface waters at concentrations ranging from ng/L to µg/L [1,2,3]. Although their occurrence is well documented, their biological impact on non-target organisms remains poorly characterized, particularly during early life stages, which may represent critical windows of vulnerability.This study investigates the individual effects of caffeine, nicotine, and clonazepam, and their mixture, on Xenopus laevis embryos exposed from the 4–8 cell stage to stage 45/46, following a modified FETAX protocol [4]. Environmental concentrations were used. Standard FETAX endpoints (survival, growth, and malformations) were integrated with additional analyses, including heart rate and locomotor activity. Oxidative stress was assessed by measuring SOD, CAT, and GPX4 enzyme activities, together with ROS production, while gene expression was evaluated by Real-Time PCR.No mortality was observed for clonazepam, whereas caffeine and nicotine showed a dose-dependent increase in mortality. Both compounds induced developmental alterations, and toxicity indices indicated teratogenic effects. The principal malformations involved gut coiling, head structure, pigment distribution, and edema. Only caffeine induced a dose-dependent increase in heart rate. Treated embryos exhibited tremors. All treatments induced ROS production and activation of antioxidant enzymes. Real-Time PCR analysis revealed alterations in genes related to morphology and brain function. Overall, these findings suggest that psychoactive contaminants can affect early vertebrate development, highlighting their ecological relevance.

References

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