Chemical effects on birds through the prism of modelling

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Résumé

Despite Rachel Carson's rallying cry in the 1960s, birds are still disappearing from the skies. They may face more threats than any other group of animals because they live in -or migrate through -every habitat on Earth. In addition to land-use change, climate change, disease and hunting, birds suffer from chemical pollution in every compartment of the biosphere. As the chemical universe only expands to include dangerous and even lethal combinations of chemicals, there is a need for trustworthy risk assessment tools, which requires to move away from classical dose-response analyses of ecotoxicity data.

To this end, scientists and regulators increasingly agree on the added value of mechanistic effect models, of which toxicokinetic (TK) and toxicodynamic (TD) models are of great interest. Such tools allow depicture of mechanistic understanding of chemical toxicity for single chemicals as well as for combined toxicity of multiple chemicals including interaction effects. Mechanistic effect models also account for time-varying exposure, allowing the user to investigate environmentally realistic exposure scenarios.

The aim of this presentation is to present a TK model capable of predicting the change in internal dose over time for different feeding patterns of birds exposed to chemicals via their diet. The model is based on a one-compartment differential equation, which accounts for the uptake of the active substance in the diet and its subsequent elimination from the body. By comparing this internal concentration with oral or ingested toxicity thresholds, a chemical can be classified as hazardous. We will also present a combined TKTD model based on the Dynamic Energy Budget (DEB) theory, which simulates the effects of chemicals on the body weight and reproduction of birds. This DEB-TKTD model captures the life cycle of a bird (from hatching to egg-laying) by describing energy assimilation from the diet and its allocation to metabolic needs according to the rule: a fraction of the energy is allocated to growth and somatic maintenance, while the remaining fraction (1 -) is allocated to maturation, maintenance of maturity and reproduction. It also accounts for an increase in the feeding rate during the laying phase to meet the energy requirements of egg production. As feed contamination can disrupt both the energy acquisition and allocation processes, we introduced an increase in reproductive costs. The basics of model formulation and the model formulation of both TK and TKTD models will be briefly described before moving on to case studies to illustrate the use of the model in practice.

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Mots-Clés: Mechanistic modelling, chemical toxicity, avian fauna, bioaccumulation, energy allocation