Under certain circumstances evolution can be highly predictable, study shows

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Researchers at Liverpool School of Tropical Medicine have shown that under certain circumstances evolution can be highly predictable, especially in terms of how creatures become resistant to dangerous toxins.

Biologists looking at the control of malaria have known for some time that mosquito populations often become resistant to insecticides designed to kill them, but in a paper published today in the journal *PNAS*, researchers examine the response of a variety of insects, reptiles, amphibians and mammals to a natural selection pressure in the form of cardiac glycosides - toxins produced by certain plants and toads for defence against predators.

Dr Nick Casewell, of LSTM's Alistair Reid Venom Research Unit, is one of the lead authors on the paper. Working with colleagues at the University of Liverpool and institutions in Australia and Israel, he has found that the evolution of toxin resistance in all of the different animals that eat these toxin-producing plants and toads is the result of highly similar molecular changes in one region of one particular gene, showing that responses to a selective challenge can lead to highly predictable evolutionary responses.

A fundamental debate within biology is whether evolution is unpredictable due the involvement of random variables, or can be constrained along predictable pathways. Convergent evolution, where similar changes occur in unrelated species, plays a central role in that

debate, but examples of convergence are rare at the molecular level and have previously been limited to groups of related species. However in this study it was found that, across all of the highly different animals studied, toxin resistance evolved because of two amino acid changes in a specific part of one gene. This particular gene produces a protein that is an essential component of the cardiac glycoside binding site, and the amino acid changes found in resistant species prevent the cardiac glycosides from binding and therefore being toxic. The fact that these changes are due to this natural selection pressure are further underlined by the reversal back to being susceptible to toxins in varanid lizards that have migrated to toad-free areas.

Dr Casewell said: "The repeatability of the process by which creatures from across the animal kingdom have become resistant to these toxins demonstrates that, in certain circumstances, evolution can be constrained along highly predicable pathways. Given the negative impact on native species in Australia following the introduction of the cane toad and the fact that toxic toads are now invading other toad-free biodiverse environments, our work could provide a simple method for testing the vulnerability of native species to invasive toxic toads. The repeatability of evolution in this system will allow us to easily determine which species have the susceptible or resistant versions of the gene, thereby allowing conservationists to prioritise the protection of species at high risk and take preventative steps necessary."

More information: Widespread convergence in toxin resistance by predictable molecular evolution, www.pnas.org/cgi/doi/10.1073/pnas.1511706112

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