

Contemporary evolution



Fundulus heteroclitus, a fish taxon often used in toxicology research. Source: NOAA

Introduction

Rapid environmental change, whether human induced such as fishing and hunting pressures, toxic chemicals, or natural climatic changes resulting in altered food availability have provided opportunities to observe rapid micro-evolutionary changes in contemporary time, or contemporary evolution. These are population level changes which tend to occur over a few centuries or much less time (depending on the species) and may be observed after only a relatively small number of generation cycles depending on the species. Well known examples of contemporary evolution include pesticide and antibiotic resistance. Yet we now know that animals other than pest species can evolve in response to rapid environmental change (including chemical exposures).

However distinguishing rapid, adaptive genetic change from phenotypic plasticity (altered phenotypic expression of a single genotype in response to environmental change – or nongenetic change) can be difficult, particularly in longer-lived species with long generation times, without rigorous analysis such as detailed studies of genetic markers (specific and well characterized portions of the genome) or long-term studies of isolated populations. Phenotypic plasticity has some advantages over genetic adaptation in that plastic phenotypes have a greater potential to reverse should conditions revert – although genetic adaptation has been observed to reverse as well. Sometimes the distinction becomes less important as phenotypic plasticity may eventually contribute to adaptive genetic change by providing some of the variability upon which selection may act.

Selected examples of contemporary evolution

Historical Studies



Peppered Moth, Lodz, Poland (Source Jerzy Strzelecki, via Wikimedia Commons)

One of the best documented examples of genetic adaptive change in response to human activity are the peppered moths of industrial England. As industries in England increasingly burned coal, the wild-type (more prevalent) light colored moths which settled onto tree trunks became more susceptible to bird predation as trees became darkened with soot. The frequency with which dark morphs of the peppered moths appeared in local populations rapidly increased. The dark-light morphs are heritable traits – meaning that changes in frequency was the result of rapid genetic adaptation. Interestingly as industrial emissions were reduced, moth populations eventually reverted back to the light-colored morph. Darwin's finches (*Geospiza fortis* and *Geospiza scandens*), studied by Peter and Rosemary Grant provide another classic example of rapid adaptation in response to environmental change caused by fluctuations in climate, which altered available food. Over a 30-year period the Grant's observed two species of Galapagos finches on Daphne Island, and found that populations experienced various episodes of genetic adaptation resulting in altered beak morphology and body size in response to food availability.

Evolution in response to chemical contamination

More recently studies of two different fish species exposed to industrial contaminants (polychlorinated biphenyls, dioxins or similar classes of chemicals) over multiple generations have evolved resistance in their response to these and other like-acting chemicals. Studies involving over twenty distinct killifish populations (*Fundulus heteroclitus*) along the eastern United States by Diane Nacci, Andrew Whitehead and others demonstrate similar functional adaptations in one of the main receptors (the aryl hydrocarbon receptor or AhR) involved in the response to these chemicals. Additionally, a population of Atlantic tomcod (*Microgadus tomcod*) residing in the Hudson River, NY has also been identified as evolving a type of AhR resistance. In both instances resistance is the product of genetic adaptation. In the case of the killifish – distinct populations were maintained and bred under the same laboratory conditions for generations (essentially a type of "common garden experiment" which is designed to eliminate confounding by environmental conditions) enabling researchers to distinguish between plasticity as a result of local environment – and genetic adaptation. In the tomcod, a specific change in the genes encoding the AhR has been identified, which in turn alter the amino acid structure, and consequentially the PCB binding ability of the receptor.

As mentioned above, there are numerous examples of evolution in pest species in response to pesticides, and in bacteria in response to antibiotics.

The Future

There is a great deal of interest in contemporary evolution (for reviews see the reading list below). Since populations may respond rapidly to overfishing or hunting pressure - understanding such rapid evolution may be useful for population managers. In addition to PCBs and like-acting chemicals animals are known to evolve resistance to industrial metal contamination and of course, pesticides. While rapid evolution has been observed in just a few vertebrate species to date, it is likely that more species will be identified as more attention is focused on this phenomenon.

As humans continue to change the world's environment, teasing apart which species are likely to become resistant to rapid change (including industrial chemicals, climate change, or other environmental changes) will enable better prediction of which species will most likely be affected (and, in the worst case go extinct), and which species will most likely survive such changes.

Further Reading

- Grant P, R Grant. 2002. Unpredictable evolution in a 30-year study of Darwin's finches. *Science* 296:707-711.
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- Kinnison M, N Hairston. 2007. Eco-evolutionary conservation biology: contemporary evolution and the dynamics of persistence. *Functional Ecology* 21:444-45
- Palkovacs E, M Kinnison, C Correa, C Dalton, A Hendry. 2011. Fates beyond traits: ecological consequences of human-induced trait change. *Evolutionary Applications* 5:183-191.

- Whitehead A, W Pilcher, D Champlain, D Nacci. 2012. Common mechanism underlies repeated evolution of extreme pollution tolerance. Proc. Biol. Sci. 279:427-433.

Source:

<http://www.eoearth.org/view/article/51cbf3647896bb431f6acb9a/?topic=51cbfc78f702fc2ba8129e7b>