How do species adapt to their surroundings?

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Several fish species can change sex as needed. Other species adapt to their surroundings by living long lives, or by living shorter lives and having lots of offspring. The ability of animals and plants to change can sometimes manifest in apparently extreme ways.

The cuckoo wrass is a fish species that lives in groups with one male and several females. If the male dies, one of the females develops into a new

male. This can clearly have obvious advantages under certain conditions.

"Normally, we think that the ability to change grows as more changes occur in the life of an average individual. But our research shows that this can work in reverse, as well. The greater the ability of an average individual to change, the longer the individual will live," says Irja Ida Ratikainen, an associate professor at the Norwegian University of Science and Technology (NTNU)'s Department of Biology.

Animals and plants that are good at adapting to the environment tend to have a longer lifespan—when longevity is advantageous. These individuals are better at coping with changes. A new article in *Nature Communications* shows what factors influence the ability of organisms to adapt to changing environments by modifying which genes dominate. The researchers looked specifically at organisms that change not only once, but that can switch repeatedly.

Ratikainen wrote the article with Hanna Kokko from the University of Zürich (UZH).

Switching back and forth

Organisms carry genes that result in certain characteristics when the genes are expressed. The possibilities for an organism to change thus reside in the genes. Animals and plants already have the necessary genes, but can turn them on and off as their surroundings change. Different varieties of gene combinations can yield different possibilities, called genotypes. One genotype can code for several different variants of a characteristic, but not all of these properties are observable. They aren't "expressed," as the experts say.

Phenotypes are traits that are observable. "Phenotypic plasticity" is the ability to develop different phenotypes in response to the environment.

Fish that change sex are an example of this ability. Some species take it a step further and can switch repeatedly. This switching back and forth between different phenotypes is called "reversible phenotypic plasticity."

"Our study mainly looks at reversible versus non-reversible plasticity, and how often an individual should invest in reversible plasticity," Ratikainen says.

Back and forth when conditions vary

Species can adapt to the environment by having some genes that dominate others. This can manifest in varied ways. Many plants adapt their leaves to the amount of sun. In the sun, the leaves become smaller and thicker, whereas in the shade, they grow larger and thinner.

Small sedentary birds that don't migrate for the winter—such as tits and Siberian jays—need to carry energy reserves on their body. But how much fat they need to carry depends on several factors, such as temperature and the danger of being caught by birds of prey and other predators.

"Physiological features can also be reversibly plastic," says Ratikainen. "This is often called acclimatization. Many animals can adjust their metabolic rate up and down as temperatures change.

Reproduce fast or live long?

Ratikainen is working to understand how animals and plants adapt when the environment changes. "This is important for learning how animals and plants tackle changes in the environment," says Ratikainen.

Understanding phenotypic plasticity is highly relevant in a world that is

changing rapidly and in big ways. In the *Nature Communications* article, Ratikainen and Kokko did not investigate specific species. Instead, they did calculations using theoretical models.

A long life doesn't always turn out to be an advantage. The most important task for individuals is to pass on their genes to the next generation by producing viable and competitive offspring. This relies on selection pressure—that is, determining the strategy that yields the greatest return for an animal's share of genes in future generations. "In cases where there's no benefit to changing the phenotype over a long period, the environment tends to select for a high reproductive rate and shorter life instead," Ratikainen says.

For species living under such conditions, it is therefore advantageous for individuals to reproduce rapidly and not live as long.

More information: Irja I. Ratikainen et al. The coevolution of lifespan and reversible plasticity, *Nature Communications* (2019). DOI: 10.1038/s41467-019-08502-9

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