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New species thanks to different ways of seeing

Eye colour and hair colour play a role in human partner choice, but visual stimuli can also determine mating preferences in the animal kingdom. In many species, the male's fortunes in the mating stakes are decided by a conspicuous breeding dress. A study of brightly coloured fish has now demonstrated that this has less to do with aesthetics than with the sensitivity of female eyes, which varies as a result of adaptation to the environment. Females more attuned to blue will choose a metallic blue mate, while those better able to see red will prefer a bright red male. These mating preferences can be strong enough to drive the formation of new species – provided that habitat diversity is not reduced by human activities.

The role of selection in the formation of new species has yet to be fully explained in evolutionary biology. The development of brightly coloured cichlid species in African lakes within only a few thousand years – a brief period on the evolutionary timescale – supports the hypothesis that mating preferences may contribute to speciation, without populations being geographically isolated from each other. In the case of cichlids, it has been suggested that selection is attributable to differences in colour perception. Compelling evidence for this theory has now been provided for the first time in a study just published in the journal *Nature*.

Seeing and being seen

In the study, evolutionary biologist Ole Seehausen (Eawag and Bern University) and his co-authors demonstrate that female cichlids from Lake Victoria whose eyes are more sensitive to blue tend to prefer blue-coloured males, while females with photoreceptors better able to detect red light choose males with red nuptial coloration. The different visual receptor pigments were distinguished by the team on the basis of DNA and protein sequences. The DNA sequence of the genes underlying the visual pigments also shows that specialization did not occur by chance but was in turn due to natural selection. Colour sensitivity differs according to the water depth at which the fish are found. Females living in deeper water are more sensitive to red, and those in shallower water are more sensitive to blue. The adaptation of visual receptors to the prevailing ambient light colour confers an advantage on fish in a certain depth range. They are better able to navigate and, for example, will find more food than non-adapted fish. At the same time, the males have evidently also adapted to this situation: males with a red breeding dress predominate in deeper water, while blue-coloured males are dominant in shallower water.

Two species are formed when ambient light changes only gradually with increasing water depth, a condition given in relatively clear waters. This means that there is sufficient room for the different genetic variants to exploit the competitive advantage conferred by their visual specialization and colour in their particular niche.

Reasons for dramatic decline of species

Besides demonstrating one way in which new species can be formed, the latest findings provide a mechanistic explanation for the dramatic loss of species diversity that has occurred in Lake Victoria over the past 25 years. Eutrophication of the lake due to agricultural runoff, deforestation and urbanization has substantially increased the turbidity of the water. As a result, ambient light changes dramatically within only a few metres of the water column. Accordingly, the different ecological niches are now so small and so close together that the mechanism of genetic adaptation can no longer operate. Thus, the authors found that at sites with turbid water, rather than separate red and blue species, an intermediate form predominated, not specifically adapted to either of the light niches. It is very likely that merging of species, driven by environmental changes, has contributed significantly to the decline of cichlid species diversity in Lake Victoria from more than 500 to the present total of around 250 species within merely 25 cichlid generations.

What is a species?

Various concepts of a species are found in evolutionary biology. What all have in common is that populations of organisms are assigned to different species if they coexist in nature over many generations in the same site without genetically merging. Numerous species hybridize occasionally but remain differentiated if mechanisms exist to restrict gene flow. The definition of a species as a group of individuals not capable of interbreeding with members of other species is a popular misconception.

Nuptial coloration in males of the cichlid species Pundamilia nyererei *(left) and* Pundamilia pundamilia *is adapted to the red or blue ambient light of their respective habitats and to the corresponding visual sensitivity of the females. © Eawag*

Seehausen O., Y. Terai, I.S. Magalhaes, K.L. Carleton, H. Mrosso, R. Miyagi, I. van der Sluijs, M.V.Schneider, M.E. Maan, H. Tachida, H. Imai & N. Okada: Speciation through sensory drive in cichlid fish. *Nature, 2008, doi:10.1038/nature07285.*

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