ScienceWatch Home
Inside This Month...
Interviews

Featured Interviews
Author Commentaries
Institutional Interviews
Journal Interviews
Podcasts

Analyses

Featured Analyses
What's Hot In...
Special Topics

Data & Rankings

Sci-Bytes
Fast Breaking Papers
New Hot Papers
Emerging Research Fronts
Fast Moving Fronts
Corporate Research Fronts
Research Front Maps
Current Classics
Top Topics
Rising Stars
New Entrants
Country Profiles

About Science Watch

Methodology
Archives
Contact Us
RSS Feeds

scienceWATCH.com
TRACKING TRENDS & PERFORMANCE IN BASIC RESEARCH

Interviews | Analyses | Data & Rankings

2010 : March 2010 - Fast Moving Fronts : Ole Seehausen on Speciation Research

FAST MOVING FRONTS - 2010

March 2010

PDF

Ole Seehausen talks with *ScienceWatch.com* and answers a few questions about this month's Fast Moving Fronts paper in the field of Environment/Ecology. The author has also sent along images of his work.

[+] enlarge

Article: Speciation through sensory drive in cichlid fish
Authors: **Seehausen, O**;Terai, Y;Magalhaes, IS;Carleton, KL;Mrosso, HDJ;Miyagi, R;van der Sluijs, I;Schneider, MV;Maan, ME;Tachida, H; Imai, H;Okada, N
Journal: NATURE, 455 (7213): 620-U23 OCT 2 2008
Addresses: Univ Bern, Inst Zool, Baltzerstr 6, CH-3012 Bern, Switzerland.
Univ Bern, Inst Zool, CH-3012 Bern, Switzerland.
Ctr Ecol Evolut & Biogeochem, Dept Fish Ecol & Evolut, Eawag, Swiss Fed Inst Aquat Sci & Technol, CH-6047 Kastanienbaum, Switzerland.
(addresses have been truncated.)

SW: Why do you think your paper is highly cited?

Speciation research is currently one of the most active fields in evolutionary and ecological research. The cichlid fish of African lakes are textbook examples of rapid speciation, but the mechanisms of rapid speciation remain elusive.

Our work on cichlids in Lake Victoria demonstrates the ecological drivers and molecular basis of divergent evolution of the visual system, which leads to speciation by a mechanism called "sensory drive" through interacting natural and sexual selection.

Our paper is perhaps the first case in cichlid fish speciation research where nearly the complete cascade of interacting mechanisms during speciation, as well as the temporal sequence in which they come into effect, could be addressed. This was possible through investigating replicate cases of speciation at variable levels of completion.

Our data also speak to the causes of species loss through reversal of speciation. Combining ecology, population genetics, experimental behavioral genetics, and molecular biology, the paper may speak to scientists in a wider range of biological disciplines.

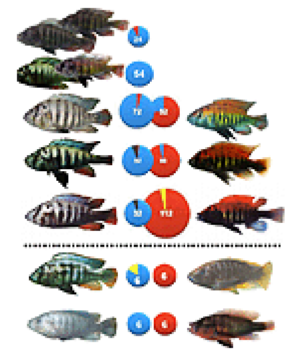
SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

It describes new discoveries and integrates these with previous knowledge.

The central theme of our paper is the demonstration that sympatric populations, which live at different water depths and had evolved different male breeding coloration, had also undergone divergent evolution in their visual pigments, adapting to the local light and matching the male breeding coloration.

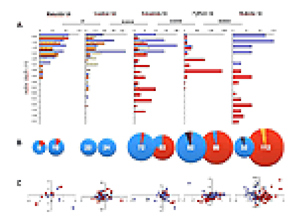
Driving the process of speciation, this adaptive divergence preceded differentiation at neutral genetic markers.

Figure 1 [+] details



The male breeding color phenotypes... ⇢

Figure 2 [+] details



Variation in the divergence between... ⇢

SW: Would you summarize the significance of your paper in layman's terms?

Theoretically, adaptation of sensory and signaling systems to local environmental signal transmission conditions can cause speciation when the sensory or signaling systems affect mate choice. This is called "sensory drive speciation."

However, empirical evidence is rare and incomplete. Speciation, in general, and sensory drive speciation in particular, is thought to usually require geographical isolation.

In our paper, we demonstrate sensory drive speciation within island populations of cichlid fish, i.e., without geographical isolation. We identify the ecological and molecular basis of divergent evolution in the cichlid visual system, demonstrate associated divergence in male coloration and female mating preferences for these, and show subsequent differentiation at neutral genetic markers of gene flow, indicating reproductive isolation and speciation (Figure 1).

Evidence is replicated in several pairs of sympatric populations, but the completeness of speciation varies from none to complete (Figure 2). Interestingly, we could explain when speciation happens and when it does not.

Variation in how quickly the ambient aquatic light changes with increasing water depth—slowly in clear water, fast in turbid water—explains most of the variation in the completeness of speciation: speciation only occurs in clear water.

Our results also provide a mechanistic explanation for the collapse of cichlid fish species diversity during the anthropogenic eutrophication of Lake Victoria when water quickly became turbid.

SW: How did you become involved in this research and were any particular problems encountered along the way?

I have been working for a number of years on speciation in Lake Victoria cichlids. In the mid-1990s, during my Ph.D. studies, I found that how strongly sympatric species were differentiated at different islands correlated with the clarity of the water. By then I showed that behavioral reproductive isolation required clear waters.

However, the precise mechanism of speciation, its association with adaptation to light conditions, and the genes involved remained unknown. I suspected that evolution in the visual system was the key. I started collaborating with groups that worked on the genetics of cichlid vision, Karen Carleton (University of Maryland in College Park, and Nori Okada (Tokyo Institute of Technology). This was back in 2001 and 2003. Work on this paper started in 2004 with Nori Okada's group.

SW: Where do you see your research leading in the future?

The exact mechanism by which adaptation in the visual system generates behavioral reproductive isolation is not yet known. This is an area of active research in my lab.

In collaboration with Martine Maan we investigate the effects on mating preferences of opsin protein sequence and expression variation, and other sensory modalities.

My collaboration with Nori Okada and Karen Carleton has broadened to comparative analyses of visual system evolution in adaptive radiations of cichlid fish in several lakes.

I have also generalized my approach beyond the specifics of evolution in the visual system to investigate the role of adaptation to different water depth in the evolution of fish species diversity more broadly, and the ways in which environmental variation co-determines when speciation happens and if species persist.

SW: Do you foresee any social or political implications for your research?

Yes. Our work demonstrates that, whether or not species persist, and whether or not speciation happens in the first place, depends on the state of the environment.

Loss of clear waters is associated with loss of adaptation to the light conditions at different depth, and with loss of genetic and ecological differentiation of species, high species diversity that characterizes African Great lakes can erode within just a few decades of pollution.

We have recently discovered very similar processes in other fish in European lakes. We are only guessing what ecosystem effects this erosion of species diversity has, but it is likely that it affects the efficacy of nutrient cycling and ecosystem resilience, and eventually, ecosystem services.

I would hope that our work contributes to the raising of an awareness among resource managers that eutrophication—the excessive increase of nutrients in a lake or other body of water—the single strongest impact of man on lakes worldwide, is a major threat to the persistence of the unique fish diversities found in many lakes.

Importantly—and this is rarely appreciated—the loss of unique species diversities of lakes is rapid and cannot be repaired by cleaning up a once-polluted lake! Prevention is the only way to preserve the diversities of lake fish.

Figures & descriptions

Ole Seehausen
Professor of Aquatic Ecology & Evolution
Division of Aquatic Ecology & Evolution
Institute of Ecology and Evolution
University of Bern
Bern, Switzerland
and
Head of Department Fish Ecology & Evolution
EAWAG Swiss Federal Institute for Aquatic Science and Technology

Centre of Ecology, Evolution and Biogeochemistry

Kastanienbaum, Switzerland

Web

KEYWORDS: LAKE VICTORIA CICHLIDS; TUNING SPECTRAL SENSITIVITY; OPSIN GENE-EXPRESSION; SEXUAL SELECTION; REPRODUCTIVE ISOLATION; MOLECULAR EVOLUTION; COLOR-VISION; DIVERGENT SELECTION; ADAPTIVE DIVERGENCE; NATURAL-SELECTION.

PDF