FAST MOVING FRONTS - 2008

July 2008

PDF

Craig Stockwell, Andrew Hendry & Michael Kinnison talk with *ScienceWatch.com* and answer a few questions about this month's Fast Moving Front in the field of Plant & Animal Sciences. The authors have also sent along images of their work.

Article: Contemporary evolution meets conservation biology
Authors: Stockwell, CA;Hendry, AP;Kinnison, MT
Journal: TREND ECOL EVOLUT, 18 (2): 94-101 FEB 2003
Addresses: N Dakota State Univ, Dept Biol Sci, Stevens Hall, Fargo, ND 58105 USA.
N Dakota State Univ, Dept Biol Sci, Fargo, ND 58105 USA.
McGill Univ, Redpath Museum, Montreal, PQ H3A 2K6, Canada.
McGill Univ, Dept Biol, Montreal, PQ H3A 2K6, Canada.
Univ Maine, Dept Biol Sci, Orono, ME 04469 USA.

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

Our paper synthesized two issues of contemporary interest to biologists and society at large in applying an emerging paradigm shift in evolutionary biology to the field of conservation biology. The traditional view of evolution as a glacially slow process has been upended over the last decade. Evolution has been shown to occur experimentally in the laboratory, but until recently it was not well known whether evolution occurred very often over contemporary time scales in nature.

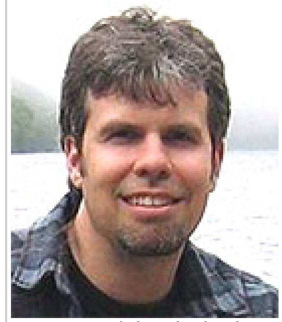
Smatterings of case studies were well known, as documented in the *Beak of the Finch* (Weiner, 1994), but the breadth of such "contemporary evolution" was uncertain. Our analysis, as well as other reviews, suggested that such contemporary evolution is relatively common (Stockwell and Weeks, 1999; Bone and Farres, 2001; Reznick and Ghalambor, 2001; Stockwell *et al.,* 2003; Kinnison, *et al.* 2007).

The goal of our paper was to look beyond simple demonstrations of contemporary evolution and illustrate its importance in the current biodiversity crisis. In particular, we noted that contemporary evolution has been shown to be associated with the same human activities driving the current extinction crisis; habitat degradation and destruction, exotic species, climate change, and overharvest. Thus, evolution in contemporary time may play a critical role in population persistence for both native and introduced species and, as such, is of relevance to conservation practitioners.

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

knowledge?

Andrew Hendry



Michael Kinnison

Our work provides a synthesis of emerging knowledge and its extension into the field of conservation biology. Contemporary evolution was well-supported theoretically and enough empirical cases were emerging to lead us to think it could be much more widespread than many people thought. We synthesized this body of knowledge, but the real novelty of our paper is that we explicitly examine the contexts for which evolution applies to problems in the field of conservation biology.

Furthermore, we consider some of the factors that may constrain or facilitate contemporary evolution. Understanding the factors that control evolution is critical to allowing practitioners to apply evolutionary principles to either facilitate or limit evolutionary responses.

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

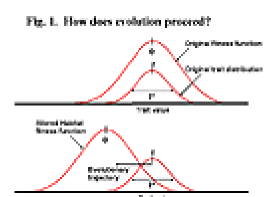
Historically, it was thought that evolution was primarily a long-term process that gave rise to modern biodiversity. For that reason conservation practitioners tended to focus on ecological or genetic threats to diversity while giving little attention to the idea that evolution might play a role in their concerns. However, classic studies with Trinidadian guppies and Darwin's finches showed that measurable evolution can occur in as little as one generation (Reznick *et al*., 1990; Grant and Grant, 1995).

Such evolution is often associated with human activities that have increased selection, but can also occur naturally when environments rapidly change due to changes such as droughts (Hendry *et al.,* 2008). In the case of the finches, a severe drought resulted in a change in the availability of seeds, so that finches with large beaks were able to forage better than finches with smaller beaks. Many more studies have since been published that provide comparable findings under different selective circumstances, such as overharvesting, introductions of exotic species, or habitat change.

Our contribution was to alert the conservation community that, because evolution often occurs on the same time scale as many conservation problems, it has real implications for preservation or restoration of species in the wild. We explored how contemporary evolution is actually expected under the very same circumstances that often lead to population declines. Moreover, we suggested how various evolutionary processes could aid or thwart their conservation objectives.

To appreciate this connection yourself, just imagine how some disturbance in the environment due to human or natural processes might change what traits are best for organisms that live there. The difference between what traits exist in the population and what traits are "optimal" under those new conditions determines the strength and direction of natural selection (see Figure 1). If that mismatch is large enough it is likely that selection may cause enough deaths or reduced reproduction to eventually threaten the population.

Figure 1: +details



However, if the population has sufficient genetic diversity (variation), then some individuals will pass on the associated genes to the next generation and thus change the average genetic traits of the population. This is contemporary evolution. Much of our paper considers examples of conservation-related issues that influence selection or genetic variation.

In a way, I guess you could say that we unveiled a new face of the biodiversity crisis. Humans are not only causing species to go extinct at unprecedented rates, we may also be rapidly changing the very traits of the ones that survive (see Hendry *et al.,* 2008 for a recent analysis of this).

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

Stockwell: During my Ph.D. studies, I documented a case study of life history evolution for non-native mosquitofish populations. As a student in a newly established program in conservation biology at the University of Nevada, I was curious as to the extent of such evolution and its potential implications for conservation biology. A short review of recent literature revealed that many case studies of contemporary evolution were associated with introduced populations. Thus, contemporary evolution has implications for the conservation of rare species which are often transplanted to new and former habitats as a conservation measure (Stockwell and Weeks, 1999).

Our research begged the question as to the role evolution played in the success and failure of conservation efforts. Independently, my collaborators, Andrew Hendry and Mike Kinnison, had also documented cases of contemporary evolution and had written two review papers that considered the analyses of such contemporary evolution (Hendry and Kinnison 1999; Kinnison and Hendry, 2001). Their analyses provided a framework for comparing rates of evolution, and further demonstrated that such case studies were rather common. It seemed that once scientists started looking, cases of contemporary evolution were very common.

In point of fact, during the last decade, my research laboratory has documented two additional cases of contemporary evolution (Stockwell and Mulvey 1998; Collyer et al. 2005).

Our collaboration was a fusion of our collective interests in evolutionary biology and conservation biology (Stockwell *et al*., 2003, 2006; Kinnison *et al.,* 2007). In reviewing the literature, it was striking that contemporary evolution was associated with the same anthropogenic forces driving the current extinction crisis. Our paper considers the breadth of cases, but also provides an overview of how evolution proceeds in wild populations. We also summarized the forces that constrain and facilitate evolution such as gene flow. Our paper, as well as other recent review papers, have collectively provided evidence that contemporary evolution is relatively common and thus upends the traditional view that populations are evolutionarily static (Reznick and Ghalambor 2001; Bone and Farres 2001; Ashley *et al.*, 2003; Stockwell *et al.,* 2003; Kinnison *et al*., 2007). Our collaboration also resulted in a manuscript to consider the relevance of contemporary evolution to restoration ecology (Stockwell *et al.* 2006).

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

This work has been well-cited in the scientific literature. Moreover, the interest in evolutionary conservation biology is reflected by the recent publication of books that take an evolutionary approach to conservation biology (Ferrière *et al.* 2004; Carroll and Fox, 2008) as well as the birth of new journals (*Conservation Genetics, Evolutionary Applications*).

However, to this point, few studies have directly applied contemporary evolution to conservation problems. The next step is for this work to be applied by conservation practitioners to real world conservation problems such as global warming and the spread of invasive species.

I am particularly interested in evaluating how evolutionary theory can be directly applied to controlling the spread of invasive species as well as mediating the impacts of invasive species on native ecosystems. My coauthors are likewise exploring conservation-related applications, as well as working on theoretical and experimental assessments of the role of contemporary evolution in ecology in general.

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

Our research places evolutionary biology in a practical light that is often under-appreciated by the general public. Certainly, the public has become aware of applied evolutionary issues like antibiotic or pesticide resistance, but often these examples are viewed as the odd workings of microbes and insects. Our work emphasizes the dynamic nature of evolution for essentially all of life as it marches lock-step with us on a changing planet. As the public comes to appreciate this practical side of evolution they will hopefully appreciate the central role evolutionary theory should play in everyone's science education.

The practical relevance to evolutionary theory of medicine has been well documented and now plays a role in the administration of antibiotics. Likewise, the management of natural systems should be considered in an evolutionary context. Traditionally, conservation biologists and ecologists alike have considered evolutionary processes as long-term concerns. However, an emerging paradigm shift is underway that allows evolutionary ecologists to consider the contemporary interaction of evolutionary and ecological processes.

Recent analyses have shown that evolution can play an important role in population dynamics and ecological processes (Hairston *et al*. 2005; Kinnison and Hairston, 2007). This area is ripe for more extensive and collaborative studies amongst evolutionary biologists, ecologists, and conservation biologists.

In the arena of global change biology, this emerging paradigm has important implications. The traditional view has been that populations unable to migrate due to habitat fragmentation would be doomed to *in-situ* extirpation. However, population persistence probability may be increased if such populations have sufficient phenotypic plasticity (Charmentier *et al*., 2008) or genetic variation to evolve *in situ*. To date, many case studies have shown that populations can respond appropriately to climate change *in situ*, but few of these studies have demonstrated if the observed response(s) were due to evolution, plasticity, or both phenomena (Gienapp *et al*., 2008, see also Charmentier *et al*., 2008).

The importance of this issue begs for more carefully designed studies to evaluate the plastic and evolutionary potential responses of populations to global climate change. Ultimately understanding the potential for populations to respond will be important for establishing an applied evolutionary approach to global climate change. For instance, the potential for species to respond to global climate change will vary widely within a community, thus which species are likely to persist will require detailed ecological and evolutionary data.

Craig A. Stockwell
Associate Professor
Department of Biological Sciences
North Dakota State University
Fargo, ND, USA

Michael T. Kinnison
Associate Professor of Biological Sciences
School of Biology and Ecology
The University of Maine
Orono, ME, USA

Andrew P. Hendry
Associate Professor
Redpath Museum and Department of Biology
McGill University
Montreal, Canada

Keywords: evolutionary biology, conservation biology, biodiversity, extinction crisis, habitat degradation, destruction, exotic species, climate change, overharvest, population persistence, evolution, Trinidadian guppies, Darwin's finches, habitat change, population dynamics, ecological processes, population persistence probability, phenotypic plasticity.

PDF

back to top

2008 : July 2008 - Fast Moving Fronts : Craig Stockwell, Andrew Hendry & Michael Kinnison

Scientific Home | About Scientific | Site Search | Site Map

FAST MOVING FRONTS - 2008

July 2008

PDF

Craig Stockwell, Andrew Hendry & Michael Kinnison talk with *ScienceWatch.com* and answer a few questions about this month's Fast Moving Front in the field of Plant & Animal Sciences. The authors have also sent along images of their work.

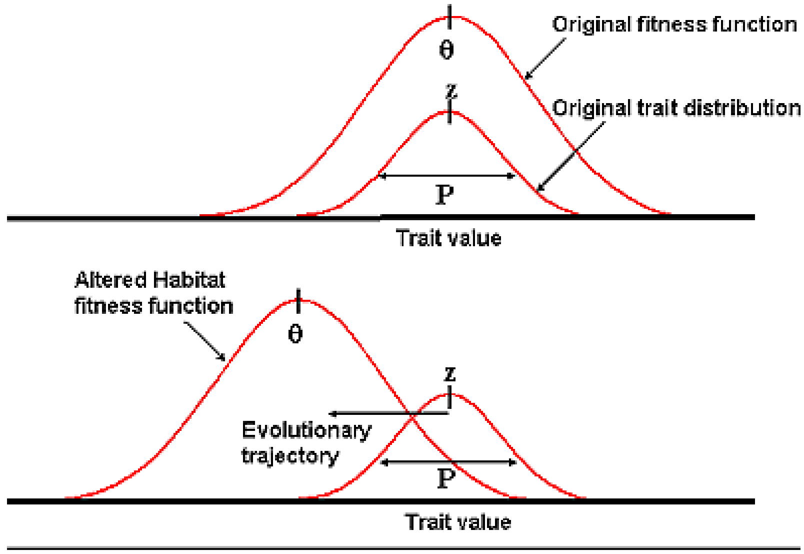
Article: Contemporary evolution meets conservation biology
Authors: Stockwell, CA;Hendry, AP;Kinnison, MT
Journal: TREND ECOL EVOLUT, 18 (2): 94-101 FEB 2003

Return to interview.

Figures and descriptions:

Figure 1:

Fig. 1. How does evolution proceed?



Return to interview.

PDF

back to top

2008 : July 2008 - Fast Moving Fronts : Craig Stockwell, Andrew Hendry & Michael Kinnison